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A DICTIONARY OF CHEMISTRY,

ON THE
BASIS OF MR. NICHOLSON'S;
IN WHICH
THE PRINCIPLES OF THE SCIENCE ARE INVESTIGATED ANEW,
AND ITS APPLICATIONS TO THE PHENOMENA OF NATURE, MEDICINE,
MINERALOGY, AGRICULTURE, AND MANUFACTURES,
DETAILED.

BY ANDREW URE, M. D.
PROFESSOR OF THE ANDERSONIAN INSTITUTION, MEMBER OF THE GEOLOGICAL SOCIETY,
&c. &c.

WITH AN
Introductory Dissertation;
CONTAINING
INSTRUCTIONS FOR CONVERTING THE ALPHABETICAL ARRANGEMENT
INTO A SYSTEMATIC ORDER OF STUDY.

FIRST AMERICAN EDITION;
WITH SOME ADDITIONS, NOTES, AND CORRECTIONS;
BY ROBERT HARE, M. D.
PROFESSOR OF CHEMISTRY IN THE UNIVERSITY OF PENNSYLVANIA.
ASSISTED BY
FRANKLIN BACHE, M. D.
MEMBER OF THE AMERICAN PHILOSOPHICAL SOCIETY AND OF THE ACADEMY OF NATURAL
SCIENCES OF PHILADELPHIA.

VOL. II.

PHILADELPHIA:
PUBLISHED BY ROBERT DESILVER, No. 110, WALNUT STREET.
1821.

Eastern District of Pennsylvania, to wit:

BE IT REMEMBERED, That on the thirteenth day of October, in the forty-sixth year of the independence of the United States of America, A. D. 1821, Robert Desilver, of the said district, hath deposited in this office the title of a book, the right whereof he claims as proprietor, in the words following, to wit:

“ A Dictionary of Chemistry on the basis of Mr. Nicholson's; in which the principles
“ of the Science are investigated anew, and its applications to the phenomena
“ of Nature, Medicine, Mineralogy, Agriculture, and Manufactures, detailed. By Andrew
“ Ure, M. D. Professor of the Andersonian Institution, Member of the Geological
“ Society, &c. &c. with an Introductory Dissertation; containing instructions for
“ converting the Alphabetical Arrangement into a systematic order of study. First
“ American edition; with some additions, notes, and corrections, by Robert Hare, M.
“ D. Professor of Chemistry in the University of Pennsylvania: Assisted by Franklin
“ Bache, M. D. Member of the American Philosophical Society, and of the Academy of
“ Natural Sciences of Philadelphia. Vol. II.

In conformity to the act of the Congress of the United States, entitled “An Act for the Encouragement of Learning, by securing the copies of Maps, Charts, and Books, to the authors and proprietors of such copies, during the times therein mentioned.”—And also to the act, entitled, “An act supplementary to an act, entitled, ‘An act for the Encouragement of Learning, by securing the copies of Maps, Charts, and Books, to the authors and proprietors of such copies during the times therein mentioned,’ and extending the benefits thereof to the arts of designing, engraving, and etching historical and other prints.”

D. CALDWELL,
Clerk of the Eastern District of Pennsylvania.

Paper, manufactured by
Joshua and Thomas Gilpin.

A
DICTIONARY
OF
CHEMISTRY.

EAGLE-STONE. A clay ironstone.

* **EARTHS.** Fifteen years ago, few substances seemed more likely to retain a permanent place in chemical arrangements, than the solid and refractory earths, which compose the crust of the globe. Analysis had shown, that the various stony or pulverulent masses, which form our mountains, valleys, and plains, might be considered as resulting from the combination or intermixture, in various numbers and proportions, of nine primitive earths, to which the following names were given:

1. Barytes. 2. Strontites. 3. Lime. 4. Magnesia. 5 Alumina, or clay. 6. Silica. 7. Glucina. 8. Zirconia. 9. Yttria.

Alkalis, acids, metallic ores, and native metals. were supposed to be of an entirely dissimilar constitution.

The brilliant discovery by Sir H. Davy in 1808, of the metallic bases of potash, soda, barytes, strontites, and lime, subverted the ancient ideas regarding the earths, and taught us to regard them as all belonging, by most probable analogies, to the metallic class. According to an ingenious suggestion of Mr. Smithson, silica, however, ought to be ranked with acids, since it has the power in native mineral compounds of neutralizing the alkaline earths, as well as the common metallic oxides. But as this property is also possessed by many metallic oxides, it can afford no evidence against the metallic nature of the siliceous basis. Alumina, by the experiments of Ehrman, may be made to saturate lime, producing a glass; and the triple compounds of magnesia, alumina, and lime, are perfectly neutral, in porcelain. We might therefore refer alumina as well as silica, to the same class with the oxides of antimony, arsenic, chromium, columbium, molybdenum, titanium, and tungsten. Alumina, however, bears to silica, the same relation that oxide of antimony does to that of arsenic; the antecedent pair acting the part of bases, while the consequent pair act only as acids.' The compound of the fluoric principle with silica is of too mysterious a nature to be employed in this discussion. The almost universal function which silica enjoys of saturating the alkaline oxides in the native earthy minerals, is exhibited, in a very striking manner, in Mr. Allan's valuable SYNOPTIC TABLES. From his fifth to his fifteenth table of analyses, the column of silica is always complete, whatever deficiency or variation may occur in the columns of the earthy *bases*. At least, only a very few exceptions need be made for the oriental gems, which consist of strongly aggregated alumina.

To the above nine earthy substances, Berzelius has lately added a tenth which he calls *thorina*.* † *See soil and analysis of soils*. †

EARTHENWARE. See POTTERY.

EAU DE LUCE, consists chiefly of the essential oil of amber and the volatile alkali.

ECHINI. Calcareous petrifactions of the echinus, or sea hedgehog.

EFFERVESCENCE is the commotion produced in fluids by some part of the mass suddenly taking the elastic form, and escaping in numerous bubbles.

EFFLORESCENCE is the effect which takes place when bodies spontaneously become converted into a dry powder. It is almost always occasioned by the loss of the water of crystallization in saline bodies.

* **EGERAN.** A sub-species of pyramidal garnet. Colour reddish-brown. Massive, sometimes crystallized in rectangular four-sided prisms, with cylindrical convex lateral planes. The prisms are long, and deeply longitudinally streaked. Shining, vitreous. Cleavage, twofold. Fracture, uneven. Feebly translucent on the edges. Scratches feldspar. Brittle. Sp. gr. 3.294. It melts into a black scoria. It occurs in a bed of

feldspar and hornblende, at Haslau, near Eger in Bohemia.*

Eggs. The eggs of hens, and of birds in general, are composed of several distinct substances. 1. The shell, or external coating, which is composed of carbonate of lime .72, phosphate of lime .2, gelatin .3. The remaining .23 are perhaps water. 2. A thin white and strong membrane, possessing the usual characters of animal substances. 3. The white of the egg, for which see Albumen. 4. The yolk, which appears to consist of an oil of the nature of fat oils, united with a portion of serous matter, sufficient to render it diffusible in cold water, in the form of an emulsion, and concrescible by heat. Yolk of egg is used as the medium for rendering resins and oils diffusible in water.

* **Eisenrahm.** Red and brown; the scaly iron ore, and scaly manganese ore.*

* **Elain.** The oily principle of solid fats, so named by its discoverer, M. Chevreul. Chevreul dissolves the tallow in very pure hot alcohol, separates the *stearin* by crystallization, and then procures the *elaïn*, by evaporation of the spirit. But M. Braconnot has adopted the simpler and probably a more exact method. By squeezing tallow between the folds of porous paper, the *elaïn* soaks into it, while the stearin remains. The paper being then soaked in water, and pressed, yields up its oily impregnation. Elaïn has very much the appearance and properties of vegetable oil. It is liquid at the temperature of 60°. Its smell and colour are derived from the solid fats from which it is extracted.

Human elaïn is yellow, without odour. Specific gravity 0.913.

Elaïn of sheep; colourless, a faint smell. Sp. gr. 0.915.

Elaïn of ox; colourless, and almost without odour. Sp. grav. 0.915.

Elaïn of hog; do. do. 0.915.

Elaïn of jaguar; lemon colour, odorous. 0.914.

Elaïn of goose; light lemon colour, little odour. 0.929.

Solubility in alcohol of sp. gr. 0.7952.

Human elaïn; 11.1 gr. by 9 gr. at the boiling point.

Elaïn of sheep; 3.79 gr. by 3 gr. at do.

Elaïn of ox; 5.8 gr. by 4.7 gr. at do.

Elaïn of hog; 11.1 gr. by 9.0 gr. at do.

Elaïn of jaguar; 3.35 gr. by 2.71 gr. at do.

Elaïn of goose; 11.1 gr. by 9.0 gr. at do.

Elaïn of the fat of ox, extracted by alcohol, yields, by the action of potash.

Of saponified fat,	92.6 parts
Of soluble matter,	7.4

Those of the other fats yield,

Of saponified fat,	89
Of soluble matter,	11

In M. Chevreul's 7th memoir on fats, published in the 7th vol of the *Ann. de Chimie et Phys.*, he gives the following as the composition of the oleates from spermaceti:—

Oleic acid -	100
Barytes -	31.24
Strontian -	23.13
Oxide of lead	100.00

If we suppose the last a suboleate, the equivalent of this oleic acid will be 28. The oil or oleic acid of the delphinus globiceps is remarkably soluble in cold alcohol; 100 parts of which of sp. gr. 0.795, at 68°, dissolve 123 of the oil. When that oil is freed by cold from a crystallizable matter, 100 parts of alcohol, sp. gr. 0.820, dissolve 149.4 of oil at the atmospheric temperature. It was slightly acid by the test of litmus, which he ascribes to the presence of an aqueous fluid. See Fat.*

* **Elaolite.** A sub-species of pyramidal feldspar. Colours, duck-brown, inclining to green, and flesh-red, inclining to gray or brown. Massive, and in granular concretions. Lustre shining and resinous. Fracture imperfect conchoidal. Faintly translucent. Hardness as feldspar. Easily frangible. Sp. gr. 2.6. Its powder forms a jelly with acids. Before the blow-pipe, it melts into a milk-white enamel. Its constituents are 46.5 silica, 30.25 alumina, 0.75 lime, 18 potash, 1 oxide of iron, and 2 water. *Klaproth.* The blue is found at Laurwig, and the red at Stavern and Friedrickswarn, both in the rock named *zircon syenite*. The pale blue has an opalescence, like the cat's eye, which occasions it to be cut into small ornaments. It is called *fettstein* by Werner, from its resinous nature. *Jameson.**

* **Elecampane.** See Inulin.*

* **Electricity.** The phenomena displayed by rubbing a piece of amber, constitute the first physical fact recorded in the history of science. Thales of Miletus, founder of the Ionic school, ascribed its mysterious power of attracting and repelling light bodies to an inherent soul or essence, which, awakened by friction, went forth and brought back the small particles floating around. In times near to our own, the same hypothesis was resorted to, by the honourable Robert Boyle. From *electron*, the Greek name of amber, has arisen the science of electricity, which investigates the attractions and repulsions, the emission of light, and explosions, which are produced, not only by the friction of vitreous, resinous, and metallic surfaces, but by the heating, cooling, evaporation, and mutual contact, of a vast number of bodies;

1. *General statement of electrical phenomena.*

If we rub, with a dry hand or a silk handkerchief, a glass tube, and then approach it to bits of paper or cotton, to feathers, or which is better, gold leaf, it will first attract these bodies, and then repel them. If the tube be held parallel to a table on which they have been laid, an electrical dance will be performed. If to the farther end of the tube we hang a brass ball, by a thread of linen, hemp, or a metallic wire, the ball will participate with the rubbed tube, in its mysterious powers. But if the ball be suspended by a cord of silk, worsted, or hair, or by a rod of glass, wax or pitch, the attractive and repulsive virtue will not pass into it.

When the atmosphere is dry, if we take in one hand a rod of glass, and in the other a stick of sealing wax, and after having rubbed them against silk or worsted, approach one of them to a bit of gold leaf floating in the air, it will first attract and then repel it. While the film of gold is seen to avoid the contact of the rod which it has touched, if we bring the other rod into its neighbourhood, attraction will immediately ensue; and this alternate attraction and repulsion may be strikingly displayed by placing the two excited rods at a small distance asunder, with the gold leaf between.

If we suspend close together, by silk threads, two cylinders of rush-pith, and touch their lower ends with either the rubbed wax or glass, the pieces of pith will instantly recede from each other at a considerable angle. If we now merely approach to the bottom of the diverging cylinders, the rod with which they had been touched, their divergence will increase; but if we approach the other rod, they will instantly collapse through their whole extent. When the rods are rubbed in the dark, a lambent light seems diffused over them, and a pungent spark will pass into a knuckle brought near them. If the person who makes these experiments happens to stand on a cake of wax, or a stool with glass feet, then on rubbing the glass tube, he will acquire the above attractive and repulsive powers; but the light bodies repelled by the tube, will be attracted by his body, and *vice versa*. Hence we see, that the *rubbing* body acquires electrical properties, dissimilar to those acquired by the substances *rubbed*.

Such is a sketch of the elementary phenomena of electricity. The science, in its modern augmentation, seems to comprehend almost every change of the corpuscular world, however minute and mysterious, as well as the long recognized and magnificent meteors of the atmosphere. Let us now take a methodical view of them, as far as the limits of our work will permit. We shall consider electrical phenomena under four heads:—

1st, Of the Excitement of Electricity, or the various means by which the electrical equilibrium is disturbed.

2d, Of the *Two Electricities*.

3d, Of the Distribution of Electricity.

4th, Of the Voltaic Battery and its Effects: calorific, or igniting; and decomposing, or the chemical agencies of electricity.

Concerning the nature of the electrical essence, we are equally in the dark as concerning the nature of caloric. The phenomena may be referred in both cases, either to a peculiar fluid, whose particles are endowed with innate idio-repulsive powers, or to a peculiar affection of the molecules of common matter.

I. *Of Electrical Excitement.*

1. The mutual *friction* of all solids, whether similar or dissimilar, and of many fluids against solids, will invariably excite electrical phenomena, provided one of the bodies be of such a nature as to obstruct the speedy diffusion of the electrical virtue. Hence we must commence with a list of electrical conductors and non-conductors.

1st, The following substances conduct or favour the rapid distribution of electricity. Those at the head of the list possess a conducting power greater than that of water, in the proportion of three millions to one.

1. Copper
2. Silver
3. Gold
4. Iron
5. Tin
6. Lead
7. Zinc
8. Platinum
9. Charcoal
10. Plumbago
11. Strong acids
12. Soot and lamp-black
13. Metallic ores
14. Metallic oxides
15. Dilute acids
16. Saline solutions
17. Animal fluids
18. Sea water
19. Water
20. Ice and snow above 0°
21. Living vegetables
22. Living animals
23. Flame
24. Smoke
25. Vapour
26. Salts
27. Rarefied air
28. Dry earths
29. Massive minerals

2d, The following is a list of electrical non-conductors, in the order of their insulating power:

1. Shell-lac
2. Amber
3. Resins
4. Sulphur
5. Wax
6. Asphaltum
7. Glass, and all vitrified bodies, comprehending diamond and crystallized transparent minerals
8. Raw silk
9. Bleached silk

10. Dyed silk
11. Wool, hair, and feathers
12. Dry gases
13. Dry paper, parchment, and leather
14. Baked wood, and dried vegetables
15. Porcelain
16. Marble
17. Massive minerals non-metallic
18. Camphor
19. Caoutchouc
20. Lycopodium
21. Dry chalk and lime
22. Phosphorus
23. Ice below 0° of Fahr.
24. Oils, of which the densest are best
25. Dry metallic oxides, including fused alkaline and earthy hydrates.

The general arrangement of the above lists is tolerably correct, though it is probable that phosphorus, when freed from adhering moisture, would stand higher among insulators.

All material substances have been usually divided into two classes; of electrics, and non-electrics. But this distinction is groundless, and calculated to mislead. Every substance is an electric, or capable by friction of exhibiting electrical phenomena. Thus, if we take any of the bodies in the first list, which are commonly called non-electrics, for instance a copper ball, and insulating it by a rod of any convenient solid in the second list, if we rub the ball with a piece of silk or worsted, we shall find it to become electrical. It will attract and repel light bodies, and will give lucid sparks to a finger which approaches it. To account for these appearances, it has been said that the electrical equilibrium which constitutes the common state of matter, is disturbed by the friction; and that one of the two bodies attracts to itself a surcharge of the electrical fluid, while the other remains in a deficient state, whence the terms of positive and negative, or plus and minus, have arisen. Many of the appearances, however, are reconciled with difficulty to a mere excess or deficiency of one fluid; and hence the hypothesis of a compound fluid, susceptible of decomposition by friction and other means, has been introduced. The resulting fluids are necessarily co-existent, the one appearing on the body rubbed, and the other on the rubber; but since the one is most usually evolved on the surface of glass, and the other on that of resins, the first has been called the vitreous, and the second the resinous electricity. These two fluids, corresponding to the positive and negative of Franklin, by their reunion produce a species of reciprocal neutralization, and electrical repose. Some recent investigations, of that profound physico-geometer M. Poisson, render the second explanation the less improbable of the two. Let us always bear in mind, however, that the hypothetical thread which we employ at present, to tie together the scattered facts of electricity, is probably very different from the chain of nature.†

There seems to be no physical quality common to the conductors, or to the non-conductors. The crystalline arrangement always introduces non-conducting qualities, more or less perfect, if we exclude the metals. Thus carbon, in the pulverulent or fibrous form, is an excellent conductor, but crystallized in diamond, it becomes an insulator. The same difference exists between water and ice; and, as is said, between pounded and compact glass. If pounded glass be indeed a conductor, it must, from my experiments, be so in a very imperfect degree. Glass, resins, and fats, which in the solid state are non-conductors, become conductors on being melted.

On the evolution of electricity by friction, is founded the construction of our common electrical machines. It was supposed at one time, that their action was connected with the oxidizement of the amalgam, which is usually applied to the face of the rubber. But Sir H. Davy having mounted a small machine in a glass vessel, in such a manner that it could be made to revolve in any species of gas, found that it was active in hydrogen, and more active in carbonic acid, than even in the atmosphere. Indeed if we recollect that the friction of surfaces of glass, silk, or sealing-wax, is sufficient to produce electrical appearances, we cannot suppose oxidizement of metal to be essential to their production. If we even impel a current of air, or a minute stream of pure mercury, on a plate of dry glass, electrical excitement will result.

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† I have never yet met with difficulty in explaining the phenomena of mechanical electricity upon Franklin's theory. An objection to it, which operates perhaps more than any other, is founded on erroneous premises. I mean that, which is grounded on the well-known phenomena of the recession from each other, of light bodies, whether electrified minus or plus. It is alleged, that the presence and absence of a principle cannot have the same effect; that, when bodies are surcharged with the electric fluid, it is easy to conceive, that they may repel each other, as in the instance of the particles of solids by a union with caloric; but it is not probable, that a deficiency of electricity will any more cause masses to separate, than that cold and heat should both cause expansion in the same solid. The truth is, that repulsion is not the cause of the separation of electrified bodies, whether excited positively or negatively. Their recession is, in either case, the consequence of an attraction between them and the surrounding medium. And it is of no importance, whether the comparative surcharge in them attract the matter in the medium around; or the comparative surcharge in this, attract them.

The electrical phenomena excited by friction, are generally so energetic, as to require nothing but bits of any light matter for their exhibition. When we have to detect the disturbance of the electrical equilibrium, occasioned by other and feebler causes, more refined *electroscopic* means are required. The most delicate of simple electroscopes consist of two oblong narrow slips of gold leaf, suspended from the centre of the brass cap of a glass cylinder, about 2 inches diameter and 6 inches long. The bottom of the cylinder should rest in a metallic sole; from which, on the opposite sides, two narrow slips of tin-foil should raise up the inner surface of the glass, to the level of the middle of the pendent slips of gold leaf. Coulomb's electroscope, which acts by the torsion of a fibre of the silk worm, suspending in a glass case a horizontal needle of shell lac, terminated in a little disc of gilt paper, is still more sensible, and is much employed by the Parisian philosophers. Aided by either of these instruments, we can observe the excitement of electrical phenomena in the following cases, independent of friction..

2. In the *fusion* of inflammable bodies. If we pour melted sulphur into an insulated metallic cup, we shall find after it concretes, that the sulphur and cup will be both electrified; the former with the vitreous, the latter with the resinous electricity; or sometimes reversely. But Messrs. Van Marum and Troostwyck, from a series of experiments which they made on a number of bodies, were led to conclude that the electricity was produced in such cases as the above, either by the friction from change of bulk, when the melted matter concretes, or from the friction which the electrical bodies undergo, when they spread upon the surfaces of other bodies, upon which they are poured in the liquid state. When glacial phosphoric acid congeals, and when calomel concretes in sublimation, electrical phenomena are produced. The experiments of Henly on the electricity excited during the concretion of melted chocolate, do not seem easily explicable on the principle of friction. When it is cooled in the tin pans into which it is first received, the electricity is strong, and continues for some time after it is removed. When it is again melted and allowed to cool, the electrical virtue is restored, but not to its former strength. After the third or fourth fusion, the electricity becomes extremely weak. When the chocolate is mixed with a little olive oil before it is poured out of the pan, it then becomes strongly electrical. Now in so far as friction is concerned, we should have the electrical phenomena as decided at the fourth fusion, as the first; and the presence of oil ought to lessen the effect, as it diminishes the friction. It is highly probable that the act of crystallization always induces a change of the electrical equilibrium; as the crystalline structure changes the electrical relations in general.

3. Electricity produced by *evaporation*.

If on the cap of the gold leaf electroscope we place a small metallic cup, containing a little water, and drop into it a red-hot cinder, the gold leaves will instantly diverge to a very considerable angle. Or if we insulate a hot crucible of iron, copper, silver, or porcelain, and pour into it a few drops of water, alcohol, or ether, on connecting the crucible with an electroscope, electrical phenomena will appear.

4. Electricity produced by *disengagement* of gas.

If into a platinum cup, resting on the top of the electroscope, we put a little dilute sulphuric acid, and then throw in some iron filings, or chalk, the gold leaves will diverge, as the effervescence becomes active. The same thing is producible with nitric acid and copper filings.

5. Electricity produced by disruption of a solid body.

If we suddenly tear asunder plates of mica, break across a stick of sealing-wax, cleave up a piece of dry and warm wood, or scrape its surface with window glass, or finally cause a bit of unannealed glass, such as a Prince Rupert's drop, to fly asunder by snapping off a bit of its tail, the electrical equilibrium will be disturbed. Most of these cases may, however, be probably referred to friction among the moleculæ. To the same head we may also refer the electricity excited by sifting various powders and metallic filings through a metallic sieve, or by dropping them on insulated plates.

6. Electricity excited by *change* of temperature.

M Haüy made the important discovery, that the property of exhibiting electrical phenomena by heat, belongs to those crystals only whose forms are not symmetrical; that is to say, of which one extremity or side does not correspond with the opposite. Thus, for example, the variety of tourmaline which he calls *isogone*, a prismatic crystal of nine sides, terminated at one end with a three-sided, and at the other with a six-sided pyramid, when exposed to the temperature of 108° Fahr. shows no sign of electricity. But if we plunge it for some minutes into boiling water, and taking it out with small forceps, by the middle of the prism, present it to the cap of the electroscope, or to a pith ball pendulum, already charged with a known electricity, we shall find it will attract it with one of its poles, and repel with the other. The three-sided pyramid possesses the resinous, and the six-sided the vitreous electricity. Although an elevation of temperature be necessary to develope this property, it is not needed for its maintenance. It will continue electrical for six hours after its temperature has fallen to the former point, especially if it be laid on an insulating support. In fact it loses its electricity, more slowly than a piece of glass, in similar circumstances.

This property of attracting light bodies when heated, was recognized by the ancients in tourmaline, which was probably their *lyncurium*. The Dutch in Ceylon gave it the name of *Aschentrikker*, from its attracting the ashes, when a piece of it was laid near the fire. It appears that a heat above 212°, impairs its electrical activity; and that it is some time before it recovers its pristine virtue. When the tourmaline is large, it is capable of emitting flashes of electrical light. The Brazilian or Siberian topaz exhibits the same phenomena by being slightly heated. The topazes of Saxony, and the blue topaz of Aberdeenshire, are electrical only by friction. Boracite, mesotype, and crystallized calamine, possess similar properties of becoming electrical with heat.

7. Electricity produced by contact of dissimilar bodies. If we take two flat discs, one of silver or copper, and another of zinc, each two or three inches diameter, furnished with glass handles, and bring them into momentary contact by their flat surfaces, we shall find, on separating them, that they are both electrified. If we touch a disc of sulphur gently heated, with the insulated copper plate, the electrical effects will be still more striking. Acid crystals, touched with metallic plates, yield electrical phenomena. Finally, crystals of oxalic acid, brought into contact with dry quicklime, develope electricity. On the excitation of electricity by contact of dissimilar chemical bodies, is founded the principle of galvanic action, and the construction of the voltaic battery. Of this admirable apparatus we shall treat in the sequel.

II. *Of the two Electricities.*

We have already stated, that the two electricities are always connate and simultaneous. If they result from the decomposition of a quiescent neutral compound fluid, we can easily see that this co-existence is inevitable. Hence also we can understand, how any body by friction, may be made to exhibit either of the two electricities, according to the nature of the rubber. The only exception is the back of a living cat, which gives vitreous electricity, with every rubber hitherto tried. To know the species of electricity evolved, it is merely necessary to communicate beforehand, to the slips of gold leaf, a known electricity, either from excited glass or sealing wax. If they be divergent with the former, then the approach of a body similarly electrified, will augment the divergence, but that of one oppositely electrified will cause their collapse.

The following is a table of several substances which acquire the vitreous electricity, when we rub them with those which follow them in the list; and the resinous electricity, when rubbed with those that precede them.

The skin of a cat.
Polished or smooth glass.
Woollen stuff or worsted.
Feathers.
Dry wood.
Paper.
Silk.
Lac.
Roughened glass.

No visible relation can be pointed out between the nature or constitution of the substances, and the species of electricity, which is developed by their mutual friction. The only general law among the phenomena, is, that the rubbing, and the rubbed body, always acquire opposite electricities. Sulphur is vitreously electrified when rubbed with every metal except lead, and resinously with lead and every other kind of rubber. Resinous bodies, rubbed against each other, acquire alternately the vitreous and resinous electricity; but, rubbed against all other bodies, they become resinously electrical. White silk acquires vitreous electricity with black silk, metals, and black cloth; and resinous with paper, the human hand, hair, and weasel's skin. Black silk becomes vitreously electrical with sealing-wax; but resinously with hare's, weasel's, and ferret's skins; with brass, silver, iron, human hand, and white silk. Woollen cloth is strongly vitreous with zinc and bismuth, moderately so with silver, copper, lead, and specular iron. It is resinous with platina, gold, tin, antimony, gray copper, sulphuret of copper, bisulphuret of copper, sulphurets of silver, antimony, and iron. When two ribbons of equal surface are excited by drawing one lengthwise over a part of the other; that which has suffered friction in its whole length, becomes vitreously, and the other resinously electrical. Dry air impelled on glass becomes resinously electrical, and leaves the glass in the opposite state. Silk stuffs, agitated in the atmosphere with a rapid motion, always take the resinous electricity, while the air becomes vitreously electrified. A ribbon of white silk, rubbed against a well dyed black one, affords always marks of vitreous electricity, but if the black silk be much worn, and the white ribbon be heated, it will yield signs of resinous electricity, and, on cooling, it will again exhibit marks of the vitreous. The general result which was deduced by M. Coulomb, from his very numerous and exact experiments on this curious subject, is the following:—

When the surfaces of two bodies are rubbed together, that whose component parts recede least from each other, or elevate least from their natural position of repose, appear, in consequence, more disposed to assume the vitreous electricity; this tendency augments if the surface experiences a transient compression. Reciprocally, that surface whose particles deviate most from their ordinary position by the violence of the other, or by any cause whatever, is, for that reason, more disposed to take the resinous condition. This tendency increases if the surface undergo a real dilatation. The stronger is this opposition of circumstances, the more energetic is the development of electricity, on the two surfaces. It grows feebler in proportion as their state becomes more similar. Perfect equality would nullify the phenomena, provided it could exist. Thus, when a dry animal or vegetable substance is rubbed against a rough metallic surface, it exhibits signs of resinous electricity. In this case, its parts are forcibly separated. When, on the other hand, it is rubbed on a polished metal, which scarcely affects its surface, or merely compresses the particles, it either affords no evidence of electricity, or exhibits the vitreous kind. Heat, by dilating the pores, acts on the surfaces of bodies, as a coarser rubber would do. It disposes them to take the resinous electricity. Thus also new black silk, strongly dyed, being rubbed against a ribbon of white silk, takes always the resinous electricity. But when the black stuff is worn, and the colour faded, if we open the pores of the white ribbon by heat, this acquires in its turn a greater tendency to the resinous electricity than the black silk, and, consequently, makes it vitreous. This disposition vanishes, as might be expected, with the accidental cause that produced it, and the white ribbon, on becoming cold, re-acquires the vitreous electricity. The black dye produces on wool the same effect as on silk. A white ribbon, rubbed against white woollen stuff, gives always signs of resinous electricity; but, against wool dyed black, it affords signs of the vitreous electricity. I have entered somewhat minutely into the detail of the apparently trifling causes which give birth to the one or the other electricity, as they may tend to throw some light on the electricities evolved among chemical bodies by friction or simple contact. It has been supposed, indeed, that uncombined acids, alkalis, and metals, are naturally and constantly in an electrized condition, the first resinously, the second and third vitreously. But of this position, there is neither probability nor evidence. The electricity produced by their contact, on an extensive surface, with other bodies, is evidently a disturbance of the pre-existing equilibrium. A wire connected with the most delicate electroscope of torsion, which moves through 90° with a force of less than 1-100,000th of a grain, will indicate no electricity, when made to touch the most energetic acid or alkaline body.

In describing the two electricities, we must not omit the interesting observations of Ehrman. There are substances of the imperfect conductor class, which are capable of receiving only one kind of electricity, when made to form links in the voltaic chain. M. Ehrman styled them *unipolar* bodies. Perfectly dry soap, and the flame of phosphorus, when connected with the *two* extremities of the voltaic apparatus, and with the ground, discharge only the resinous electricity. The flames of alcohol, hydrogen, wax and oil, discharge, under like circumstances, only the vitreous electricity. All these bodies, however, when connected with only *one* pole of the pile, and with the ground, destroy the divurgence of the leaves of the electroscope attached to that pole. To render these results manifest, insulate in dry weather a battery of about 200 pairs of plates. Connect with each extreme pole, the cap of a gold leaf electroscope, by a moveable wire. When either electroscope is brought in contact with soap communicating with the ground, the slight divergence of the gold slips ceases. But, when the soap is connected with both electroscopes, and also with the ground, the divergence of the leaves of the electroscope, attached to the zinc end or vitreously electrified pole, will continue, while the leaves of the other electroscope will collapse. The inverse order of effects occurs, or the zinc electroscope collapses, when the flame of a taper is connected with both electroscopes, and with the ground.

Mr. Brande, in an ingenious paper published in the Phil. Trans. for 1814, has endeavoured to explain the curious phenomena, with regard to flames, in another way. As some chemical bodies are supposed by him to be naturally in the resinous, and others in the positive electrical state, he supposes that the positive flame will be attracted and neutralize the negative polarity, while the negative flame will operate a similar restoration of the equilibrium at the positive pole. To determine the truth of this hypothesis, he placed the flames of various bodies between two insulated brass spheres, containing each a delicate thermometer. His first experiment verified Mr. Cuthbertson's observation, that the flame of a candle communicates its heat chiefly to the negative ball, both being feebly electrified by a cylindrical machine of Nairne's construction.

Flames attracted by the

Positive Ball.	*Negative Ball.*
Phosphuretted hydrogen, slightly.	Olefiant gas.
Carbonic oxide in a small stream, doubtful.	Sulphuretted hydrogen, slightly; its sulphurous acid vapour passed off to the positive ball.
Ditto in large stream.	Arsenuretted hydrogen; its arsenious acid passed feebly to the other ball.
The acid from the flame of sulphur.	Hydrogen, result doubtful from equality of attraction.
Flame and acid fumes of phosphorus.	Flame of carburet of sulphur; its acid fumes passed to the positive.
Stream of muriatic acid gas, shown by coating the balls with litmus paper.	Flame and alkaline fumes of potassium.
Stream of nitrous acid.	Flame of benzoic acid.
Vapour of benzoic acid.	Flame of camphor.
Ditto of amber.	Flame of resins.
	Flame of amber.

"The flame of oil, wax," &c. says Mr. Brande, "must be considered as consisting chiefly of those bodies in a state of vapour; and their natural electricities being positive, it is obvious, that when connected with the *positive* pole of the battery, and with a gold leaf electrometer, the leaves will continue to diverge; but when applied to the negative pole, that electrical state will be annihilated by the inherent positive energy of the flame, and consequently the leaves of the negative electrometer will not diverge. On the other hand, the flame of phosphorus is negatively unipolar. Now it has been shown that this flame, (owing probably to the rapidity with which it is forming a powerful acid, by combination with a large quantity of oxygen), is attracted by the positively electrified surface, and consequently that it is itself negative, so that it would transmit negative electricity to the electrometer, but would annihilate the negative power, and thus appear as an insulator under the particular circumstances which M. Ehrman has described." I shall not stop to investigate the justness of these ingenious conclusions. They do not affect the unipolarity of dry soap; which on Mr. Brande's theory of that of flames, should be naturally and permanently in the state of positive electricity; which we know it not to be.

III. *Of the Distribution of Electricity.*

Under this head we shall be able to arrange several important phenomena, which, by their disjunction, authors have frequently rendered complex and difficult of comprehension. We shall treat in the first place, of the distribution of *either* electricity, insulated in one body, and in a system of bodies in contact; in the second place, the distribution of electricity in a system of contiguous bodies, not in contact.

1. If we communicate electricity to an insulated metallic sphere, we shall find the whole electric power diffused over its surface, and the particles in its interior, absolutely devoid of the least electric virtue. Let the ball of iron or brass have a hole of about an inch diameter, reaching to its centre. Then on touching the centre, with a metallic spherule attached to the end of a needle of lac, and instantly applying it to a delicate electroscope, we shall perceive no sign of electricity whatever. If the spherule, however, touch the outer edge of the hole, or the surface of the globe at any point, it will acquire a very manifest electricity. Hence, if we apply for a moment to the surface of an electrified 24 pound shot, two hemispherical cups of tinfoil, furnished with insulating handles, we shall find that the whole electrical virtue has passed into the cups, whose weight may not equal the ten-thousandth part of that of the ball. This distribution is totally independent of the nature of the substance, and is deducible from the law discovered by Coulomb, that electrical attractions and repulsions, are inversely proportional to the squares of the distances.

If the body be spherical, the exterior electrical stratum, which always coincides with the surface of the body, will be the same with the thin stratum in its interior. If the proposed spheroid, be an ellipsoid, the inner surface of the electrical stratum, will be also a concentric and similar ellipsoid; for it is demonstrated, that an elliptical stratum, whose surfaces are thus concentric and similar, exercises no action on a point placed in its interior. The thickness of the layer in each of its points, is found generally determined by this construction. It hence results, that this thickness is greatest at the summit of the greater axis, and least at the summit of the smaller.

The thicknesses corresponding to the different summits, are to each other, as the lengths of their respective axes.

2. Were the atmosphere, and the glass support, perfect non-conductors, the above distribution would continue till some other body was brought near to, or in contact with, the ball. But the surface of even lackered glass, yields slowly to the idio-repulsive power of the electrical fluid; and the atmosphere, partly by its aqueous particles, and partly by its own feebly conducting power, continually robs the globe of its electricity. The immediate aërial envelope no sooner acquires electric impregnation, than it recedes, and is replaced by a new sphere of gaseous particles. By this intestine aërial movement of repulsion and attraction, the ball, in a short time, loses its excess of vitreous or resinous electricity, and resumes the neutral state. By placing it in the centre of a dry glass receiver, the period of electrization may be prolonged, but, sooner or later, the electric equilibrium is restored between it, and the surrounding matter.

3. If we bring into contact with the above electrized ball, an unelectrified one of the same bulk, but of a very different weight, we shall find an equal distribution to take place between them. An insulated disc or spherule applied to the surface of each, will be capable of affecting a graduated electrometer of torsion, to the same degree. We thus perceive that bodies do not act on electricity, by any species of elective attraction or affinity. They must be regarded merely as vessels, in which this power is distributed, agreeable to the laws of mechanics.

When the above globes are separated, their electricities diffuse themselves uniformly about them, and the quantities are found equal when the surfaces are so. But if the surfaces be unequal in any given ratio, it then happens that the quantity of electricity varies in a different ratio, which is less than that of the surfaces. Thus Coulomb ascertained, that when the surface of the smaller globe was nearly one-fifteenth of that of the larger, its quantity of electric fluid was one-eleventh. The following is his general table of results:—

Surface of Sphere.	*Density in little sphere, whose surface* = 1.
1	1
4	1.08
16	1.30
64	1.65
Infinite,	less than 2.00
Do. calculated by M. Poisson,	1.65

The difference therefore can never amount to two. He placed two globes, each of two inches diameter, in a line with a globe of eight inches diameter; the two smaller ones being in contact, and one of them with the larger. He found that the quantity of electricity of the smaller globe, most distant from the greater, was to that of the intermediate, as 2.54 to 1. Four globes of two inches being placed in a row, successively in contact with each other, and with a globe of eight inches diameter, the ratio of the quantities of electricity taken by the small globe, farthest from the large one, and that nearest it, was found to be 3.4 to 1. Having placed 24 globes, each of two inches diameter, in a like series with the larger globe, Coulomb compared the 24th little globe, that is to say, the last in the row, with others in the same row, and the results were as follow:—

24th to the 23d as 1.49 to 1
24th to the 12th as 1.7 to 1
24th to the 10th as 2.1 to 1
24th to the 1st
which was in contact
with the large globe, as 3.72 to 1
24th to that of
the large globe, as 2.16 to 1.

When two electrified spheres, of equal size in contact, are examined as to the state of the electricity on the different points of their surfaces, we have the following relations:—

Position of the points compared.		*Ratio of the second thickness to the first.*
90° and	20°	insensible
90	30	0.2083
90	60	0.7994
90	90	1.0000
90	180	1.0576

If the diameters of the two globes be as 2 to 1.

90° and	30°	insensible
90	60	0.5882
90	90	1.0000
90	180	1.3333

That in ordinary cases, electricity is confined on the surfaces of bodies, not merely by the non-conducting faculty of the air, but by a species of mechanical pressure which air exercises, becomes evident, when we lessen the density of the air by exhaustion. Though the conducting aërial particles are thus greatly diminished in number, rendering the insulation apparently more complete, yet the electric power now emanates with vast rapidity, from the electrized ball, in visible coruscations. Rarefied air is therefore a good conductor.

4. By touching various points of insulated electrized bodies with a little disc of metallic foil, cemented to the end of a needle of lac, which he applied to his electrometer, M. Coulomb ascertained the variation of electrical density, that exists at different points on the surfaces of bodies, of different forms and magnitudes. He thus

found, that towards the extremities of all oblong conducting bodies, whether thin plates, prisms, or cylinders, there is a rapid augmentation of the electricity. He insulated a circular cylinder of two inches diameter and thirty inches in length, terminated at each end with a hemisphere. By comparing the quantities of electricity accumulated at the centre, and at various points, near to its extremities, he found

	Ratio of the second electrometric torsion to the first.
Touched at the middle and 2 inches from the end, -	1.25
And 1 from do. -	1.80
And at the end, -	2.30

When the cylinder becomes more and more slender towards its extremities, the increase of electricity becomes in these parts more considerable, and more rapid. Lastly, if the extremity of the cylinder be prolonged like the apex of a cone, the accumulation which occurs at this point becomes so strong, that the resistance of the air is no longer sufficient to retain the electricity on the surface of the conducting body, and it escapes in luminous coruscations, visible in the dark. In this case, the uniform distribution of electricity, extends to a very small distance from the pointed extremity. We thus perceive why bodies furnished with sharp-projections, rapidly lose the electricity communicated to them. In like manner, a circular plate of five inches diameter, when electrified, has at its centre an intensity of 1, at one inch from it 1.001, at two inches 1.005, at three inches 1.17, at four inches 1.52, at four and a half inches 2.07, and at the border 2.9 times that of the centre. We can thus understand how electrical machines, furnished with elongated prime conductors, furnish very vivid sparks.

2. Of the distribution of electricity among contiguous bodies, not in contact.

Let us examine first what happens when two electrified spheres separated from contact, are removed to a little distance from each other. A very remarkable phenomenon is then developed. We have seen, that during contact, the electricity is of the same nature on the two spheres. To fix our ideas, left us suppose it to be vitreous. We have likewise seen that it is null at the point of contact. Now at the instant of separating the two spheres, if their dimensions be unequal, this nullity no longer exists. A part of the combined electricity of the small sphere is decomposed, and that which is of a nature opposite to the electricity of the great sphere, namely the resinous in the present example, is carried towards the point where the contact occurred. This effect diminishes according as we remove the two spheres from one another, and it becomes null at a certain distance, which depends on the ratio of their *radii*. Then the point of the little sphere, where the contact was, passes back into its state during the contact, that is to say, it has no species of electricity. Departing from this term, if we augment the distance, the electricity remains of the same nature over the whole surface of the little sphere, and that nature is the same as during the contact. These phenomena are always peculiar to the smaller of the two spheres, whatever may be the quantity of electricity communicated to them. On the larger sphere, the electricity is always and throughout of the same kind, as at the moment of contact.

In an experiment made by Coulomb, the great globe being eleven inches, and the small four in diameter, the opposition of the two electricities continued till the distance became two inches. When the diameter of the latter was only two and a half inches, the opposition continued till the distance became two and a half inches, but not beyond. When the globes are equal, these peculiarities do not take place.

When two oppositely electrized spheres are gradually approached towards each other, the thickness of the electric coating at the nearest points of their two surfaces becomes greater, and increases indefinitely as their distance diminishes. The pressure exercised by the electricity, against the plate of air interposed between the two bodies, augments progressively, and terminates by overcoming the resistance of the air. The fluid then escaping under the form of a spark or otherwise, must pass previous to the actual contact from one surface to the other.

This action at a distance is a key to the principal phenomena of electricity.

In our first inquiries we remarked, that electrized bodies attract, or seem to attract, all the light matters presented to them, without its being necessary to develop in the latter the elective faculty, either by friction or communication. But now we must conceive that this development is spontaneously effected, by the mere influence at a distance of the electrized body, on the combined electricities of the small bodies around. Thus all the attractions, whether real or apparent, which we observe, take place only between electrized bodies.

When therefore an insulated conducting body B, which is in the natural state, is put in presence of another insulated electrized body A, the electricity distributed on the surface of A, acts by influence on the two combined and quiescent electricities of B, decomposes a quantity of them proportional to the intensity of its action, resolving it into its two constituent principles. Of these two electricities become free, A attracts the one, and repels the other. The second is carried to the portion of the surface of B, which is most remote from A; the first to the contiguous surface. These two electricities react in their turn on the free electricity of A, and even on its combined electricities, of which one part is decomposed by this reaction, and is separated, if the body A be also a conductor. This new separation induces a new decomposition of the combined electricity of B, and thus in succession, till the quantities of each principle become free, or the two bodies come into an equilibrium, by the balancing of all the attractive and repulsive forces, which they mutually exercise, in virtue of their similar or dissimilar nature.

If A is vitreously electrized, and the conductor B is a cylinder, the end of it adjoining to A will be resinous, and the remote end vitreous, while the middle portion will be nearly neutral.

If we now touch this remote end with a third insulated conductor C, in the natural state, and then remove it, we shall find it charged with vitreous electricity. Or if we touch the remote end of the second conductor with a finger, and after withdrawing it separate the first and second insulated conductors, to a considerable distance, we shall find that B has acquired electricity, independent of the presence of A. Had we not touched it, however, then on putting them asunder, B, no longer exposed to the influence of A, would instantly recover its natural state. The two decomposed electricities would in this case flow back from the extremities, and recombining, restore the equilibrium. If A was vitreous, the touch of an unelectrified finger, would make B pass into the resinously electrical state, by opening a channel, so to speak, for the repelled vitreous electricity to escape. We see also, how this action and reaction may prodigiously increase the intensity of an electricity originally very feeble. On this principle we can at pleasure communicate to an insulated conductor, either of the electricities, from one electrified body or source.

Thus having excited a stick of sealing-wax by rubbing it on the sleeve of our coat, we may make this resinous electricity produce either the resinous or the vitreous state, in the gold leaves of an electroscope. If we hold the stick at a little distance, above the cap of the electroscope, the leaves will immediately diverge, and if we then remove it, they will instantly collapse. If we now touch the cap for an instant with the sealing-wax, the leaves will acquire the same electrical state; they will continue divergent, with resinous electricity. Let us restore the natural state, by touching the cap with our finger. Holding again the sealing-wax, a little above the electroscope, let us then touch its cap for a moment with our finger, and after removing it withdraw the wax, we shall perceive the leaves continue to diverge, and on trying the species of electricity, we shall find it to be the vitreous; for the approach of excited wax will make the divergence diminish, while that of excited glass will make it increase.

These reciprocal attractions, repulsions, and decompositions of the electrical compound, explain perfectly the action of the condenser of electricity as contrived by Œpinus or Volta, and improved by Cuthbertson; of the electrophorus; of the Leyden jar; and in some measure, of that mysterious apparatus, the voltaic battery. To this subject, all our preceding electrical researches may be considered as merely introductory: for this instrument constitutes the great link between electricity and chemistry, deriving probably its uninterrupted series of impulsive discharges, and consequently its marvellous power of chemical analysis, from the conjoined agencies of electricity, and elective attraction.

IV. *Of Voltaic Electricity.*

The accidental suspension of recently killed frogs, by copper hooks to the iron palisades of his garden, was the occasion of the celebrated Galvani observing certain convulsive movements, in the limbs of the animals, which no known principle could explain, and thenceforth of opening up to mankind, a rich and boundless field in physical science.† As the practical nature of this work precludes us from entering into historical details, we shall at once proceed to describe the present state of *voltaic electricity* and *electro-chemistry*. Galvani had ascribed the muscular movements to a series of discharges, of a peculiar electricity, inherent and innate in living beings, to which the name animal electricity, or the more mysterious term galvanism, was for some time given. Volta proved, that the phenomena proceeded from the contact of the two dissimilar metals, copper and iron, producing such a disturbance of the electrical equilibrium, as was sufficient to affect the most delicate of all electroscopes, the irritability of a newly killed frog, though it was insensible to every electroscope of human construction. He fully verified this fine theory, by showing, that a few contacts of the dissimilar metals, zinc and silver, in the form of discs, furnished with insulating handles, were capable of affecting the common condenser of electricity. Galvani, however, anxious to defend his own hypothesis, which linked his name to the science, adduced some curious facts, which proved, that muscular convulsions could be produced in the limbs of dead frogs, altogether independent of metals. This led Volta to the further discovery, that other dissimilar bodies, besides metals, were capable by contact of disturbing the electrical equilibrium.

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† According to Wilkinson's history of Galvanism, the first galvanic phenomenon observed, was that of the taste excited on the tongue by pieces of silver and zinc; and Galvani was first led into this path of investigation, which has immortalized his name, by the convulsions observed in some frogs, prepared for soup, and brought accidentally near to an electrical machine, from which sparks were proceeding.

Since a slender rod of silver and of zinc, touching each other at one of their ends, and at the other brought into contact with the nerve and muscle, or spine and toes of a dead frog, could excite powerful convulsions, it occurred to Volta, that a repetition on a more extended surface, of that simple series of two metals and moisture, might produce a combined effect, capable of being felt by the human hand. By a most philosophical prosecution of his own principle, he happily succeeded in constructing, by regular alternation of discs of silver, zinc, and moistened cloth or pasteboard, reared in a columnar form, the electro-chemical pile and battery, which will associate the name of Volta to that of Galvani, through each succeeding age. The compound metallic arcs of copper and zinc, with which he connected a circle of cups containing salt-water, to form his *couronne des tasses*, may be regarded as the same apparatus, in a horizontal, instead of a columnar arrangement. The former construction was happily modified by Mr. Cruickshanks into the voltaic trough; while the latter has suggested the arrangement of parallel porcelain cells, into which a concatenated series of compound metallic plates is immersed.

Amid the crowd of philosophers, who, after Galvani and Volta, entered this arduous field, two are pre-eminent for the ingenuity and success of their investigations. Dr. Wollaston and Sir H. Davy. The first had the singular merit of tracing up the analogy between the mysterious operations of galvanic, and of common electricity; and afterwards invented an apparatus, by which this agent can excite vivid ignition, in almost a microscopic compass. Of the discoveries made by Sir H. Davy, in voltaic electricity, and in chemistry, by the sagacious application of its unlimited powers, it is difficult to speak in the cold language of philosophy. They probably surpass in importance, as they do in splendour, the united discoveries of preceding chemists; and when the breath of contemporary envy shall sink into the grave, they will shine forth on the diadem of English science, companion gems to the diamond of Newton.

I shall now endeavour to give a brief survey of voltaic phenomena, conducting my steps, by the researches of these philosophers.

There are six great eras in electro-chemical science:—1. Its first discovery by Galvani; 2. Volta's discovery of the contact of dissimilar metals, disturbing the electric equilibrium; 3. Volta's invention of the pile; 4. The *chemical* power of this instrument, first observed by Messrs. Carlisle and Nicholson, in the decomposition of water; 5. The identity of these chemical effects with those producible by common electricity, first discovered and demonstrated by Dr. Wollaston, in his admirable "Experiments on the Chemical Production and Agency of Electricity;" and lastly, The general laws of electro-chemical decomposition and transfer, revealed by Sir H. Davy, in a series of memoirs, equally remarkable for genius and industry. It is but justice to this philosopher to state that the germ of his most splendid discoveries, was manifestly formed and exhibited, immediately after the construction of the pile was announced. Volta's celebrated letter, descriptive of his invention, is dated Como, March 20, 1800; it was published in the Philosophical Transactions, in the autumn of that year; and in Nicholson's Journal, for September of the same year, we have an important communication from Sir H. Davy, then Superintendent of the Pneumatic Institution at Bristol.

Mr. Carlisle having been favoured, by Sir Joseph Banks, with a private perusal of Volta's letter, constructed a pile; and in the beginning of May, assisted by Mr. Nicholson, made several experiments on the decomposition of water, and the reddening of litmus by its means; but out of delicacy to the Professor of Pavia, these were not published till July. Mr. Nicholson, in a masterly account of Volta's discovery, Mr. Carlisle's, and his own, says, "We had been led by our reasoning on the first appearance of hydrogen, to expect a decomposition of the water; but it was with no little surprise that we found the hydrogen extricated at the contact with one wire, while the oxygen fixed itself in combination with the other wire, at the distance of almost two inches. This new fact still remains to be explained, and seems to point at some general law of the agency of electricity in chemical operations."

"Struck," says Sir H. Davy, "with the curious phenomena noticed by Messrs. Nicholson and Carlisle, namely, the apparent separate production of oxygen and hydrogen from different wires, or from different parts of the water completing the galvanic circle, my first researches were directed towards ascertaining, if oxygen and hydrogen could be separately produced from quantities of water, not immediately in contact with each other." He then proceeds to describe very ingenious and decisive experiments, in which he produced the distinct evolution of oxygen and hydrogen, from water contained in two separate glasses, even when the communication was made between them, through dead muscular fibre, through his own body, or even through three persons. He next submits water, deprived of its loosely combined oxygen by boiling, to the voltaic pile, and obtains its two constituents in a pure state.

"Reasoning," says he "on this separate production of oxygen and hydrogen, from different quantities of water, and on the experiments of Mr. Henry, junior, on the action of galvanic electricity on different compound bodies, I was led to suppose, that the constituent parts of such bodies (supposing them immediately decomposable by the galvanic influence), might be separately extricated from the wires, and in consequence, *obtained distinct from each other*." After submitting solution of potash to the voltaic powers of 100 pairs of small plates, without obtaining the expected decomposition, he observes, "Surprised at these results, which proved that no decomposition of potash had taken place, and that that substance in this mode of operating, only enabled the galvanic influence to extricate oxygen and hydrogen more rapidly from water, I was induced to operate upon this substance in the way of direct communication." Still, only the water was decomposed, as we might now expect. He finally describes the decomposition of water of ammonia, as well as sulphuric and nitric acids, and concludes by correcting an error into which Dr. Henry had fallen, concerning a supposed decomposition of potash. "If," says he, "the ratio between the quantities of oxygen and hydrogen produced from the different wires, be always the same, whatever substances are held in solution by the water connected with them, this nascent hydrogen will become a powerful and accurate instrument of analysis."

Dr. Wollaston coated the middle of a very fine silver wire, for two or three inches, with sealing-wax, and by cutting it through in the middle of the wax, exposed a section of the wire. The two coated extremities of the wire thus divided, were immersed in a solution of sulphate of copper, placed in an electric circuit between the two conductors of a cylindrical machine; and sparks taken at 1-10th of an inch distance, were passed by means of them through the solution. After 100 turns of the machine, the wire which communicated with (what is called) the negative conductor, had a precipitate formed on its surface, which on being burnished, was evidently copper; but the opposite wire had no such coating.

Upon reversing the direction of the current of electricity, the order of the phenomena was of course reversed; the copper being shortly redissolved by assistance of the oxidating power of positive electricity and a similar precipitate formed on the opposite wire.

A similar experiment, made with gold wires $\frac{1}{100}$ of an inch diameter, in a solution of corrosive sublimate, had the same success.

If a piece of zinc and a piece of silver have each one extremity immersed in the same vessel, containing sulphuric or muriatic acid diluted with a large quantity of water, the zinc is dissolved and yields hydrogen gas by decomposition of the water; the silver not being acted upon has no power of decomposing water; but whenever the zinc and silver are made to touch, or any metallic communication is made between them, hydrogen gas is also formed at the surface of the silver. Any other metal beside zinc, which, by the assistance of the acid employed, is capable of decomposing water, will succeed equally, if the wire consists of a metal on which the acid has no effect.

Experiments analogous to the former, and equally simple, may also be made with many metallic solutions. If, for instance, the solution contains copper, it will be precipitated by a piece of iron, and will appear on its surface. Upon silver merely immersed in the same solution, no such effect is produced; but as soon as the two metals are brought into contact, the silver receives a coating of copper.

In the explanation of these experiments, says Dr. Wollaston, it is necessary to advert to a point established by means of the electric pile. We know that when water is placed in a circuit of conductors of electricity, between the two extremities of a pile, if the power is sufficient to oxidate one of the wires of communication, the wire connected with the opposite extremity affords hydrogen gas. Since the extrication of hydrogen in this instance, is seen to depend on electricity, it is probable that, in other instances, electricity may be also requisite for its conversion into gas. It would appear, therefore, that in the solution of a metal, electricity is evolved during the action of the acid on it; and that the formation of hydrogen gas, even in that case, depends on a transition of electricity between the fluid and the metal.

We see, moreover, in the experiments with zinc, that this metal, without contact of any other, has the power of decomposing water; and we can have no reason to suppose that the contact of the silver produces any new power, but that it serves merely as a conductor of electricity, and thereby occasions the formation of hydrogen gas. In the next experiment, the iron by itself has the power of precipitating copper by means, it is presumed, of electricity evolved during its solution; and here likewise the silver, by conducting the electricity, acquires the power of precipitating the copper in its metallic state.

The explanation now given, with regard to these voltaic combinations of single pairs, receives additional confirmation from the above comparative experiments with common electricity. These show, that the same transfer of chemical power, and the same apparent reversion of the usual order of chemical affinities in the precipitation of copper by silver, may be effected by a common electrical machine.

The chemical agency of common electricity is thus proved to be the same with the power excited by chemical means; but since a difference had been observed in the comparative facility with which the pile of Volta decomposes water, and produces other effects of oxidation and deoxidation of bodies exposed to its action, Dr. Wollaston was at pains to remove this difficulty, and succeeded in producing a very close imitation of the galvanic phenomena, by common electricity.

It had been thought necessary to employ powerful machines, and large Leyden jars, for the decomposition of water; but when he considered that the decomposition must depend on duly proportioning the strength of the charge of electricity to the quantity of water, and that the quantity exposed to its action at the surface of communication, depends on the extent of that surface; by reducing this, he effected the decomposition of water by a much smaller machine. Having procured a small wire of fine gold, and given it as fine a point as he could, he inserted it into a capillary glass tube, and after heating the tube so as to make it adhere to the point, and cover it in every part, he gradually ground it down, till with a pocket lens he could discover that the point of the gold was exposed.

The success of this method exceeding his expectations, he coated several wires in the same manner, and found, that when sparks from the conductors before mentioned were made to pass through water, by means of a point so guarded, a spark passing to the distance of one-eighth of an inch, would decompose water, when the point exposed did not exceed 1-700th of an inch in diameter. With another point which he estimated at 1-1500th, a succession of sparks, 1-20th of an inch in length afforded a current of small bubbles of air. But in every way in which he tried it, he observed that each wire gave both oxygen and hydrogen gas, instead of their being formed separately as by the electric pile.†1

He is inclined to attribute the difference in this respect to the greater intensity with which it is necessary to employ common electricity; for that positive and negative electricity so excited, have each the same chemical power as they are observed to have in the electric pile, may be ascertained by other means.†2

In the precipitation of copper by silver, an instance of deoxidation by negative electricity has been mentioned; the oxidating power of positive electricity may be also proved by its effect on vegetable colours.

Having coloured a card with a strong

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†1 In my memoir on my theory of galvanism, I suggested, that the decomposition of water, which Wollaston effected by mechanical electricity, might not be the effect of divellent attraction, like those excited by the poles of a voltaic pile, but of a mechanical concussion, as when wires are dispersed by the discharge of an electrical battery. This opinion is confirmed by the circumstance here mentioned, that hydrogen and oxygen were given off at each wire; and also by some experiments, of Mr. Singer, mentioned in his electricity, page 136. According to him, brass was separated by an electrical discharge into copper and zinc; metallic oxides were reduced, especially oxide of tin. It cannot be alleged, that, in such decompositions, the divellent polar attractions are exercised like those which characterize the action of wire proceeding from the poles of a voltaic apparatus. The particles were dispersed from, instead of being attracted to, the wires, by which the influence was conveyed among them. This being undeniable, it can hardly be advanced, that we are to have one mode of explaining the separation of the elements of brass by an electrical discharge, another of explaining the separation of the elements of water by the same agent; one rationale when oxygen is liberated from tin, and another when liberated by like means from hydrogen.

†2 Yet mechanical electricity is always far more intense than galvanic, if we may judge by its striking distance, or length of sparks, which is three hundred times greater with a good plate machine of ten inches, than with the great pile of the Royal Institution. Indeed many who adopt Wollaston's conclusions, and among others Sir H. Davy, consider the difference between the fluid, when evolved by a pile, and by a machine, to arise from its being more intense in the one case, and more copious in the other. Wollaston is, therefore, supposed to produce a resemblance in the effects, by increasing the principal feature of discordancy in their causes.

infusion of litmus, he passed a current of electric sparks along it, by means of two fine gold points, touching it at the distance of an inch from each other. The effect, as in other cases, depending on the smallness of the quantity of water, was most discernible when the card was nearly dry. In this state a very few turns of the machine were sufficient to occasion a redness at the positive wire, very manifest to the naked eye. The negative wire being afterwards placed on the same spot, soon restored it to its original blue colour. By the voltaic pile, the same effects are produced in a much less time.

Dr. Wollaston concludes, that all the differences discoverable in the effects of galvanic and common electricity, may be owing to the former being less intense, but produced in much larger quantity.

A wire connected with the zinc extremity of a voltaic pile of 50 or 100 pairs, being made to touch the brass cap of the electroscope, will cause the gold leaves instantly to diverge with vitreous electricity; a wire connected with the copper end will make them diverge with resinous electricity; but a wire from the middle of the pile will have no effect on the electroscope.

If wires of platinum from the opposite extremities of the pile be introduced into any solution of a neutral salt, containing acid, united to alkaline, earthy, or common metallic matter; acid matter will collect round the vitreously electrified or positive surface; alkali, earth, or oxide, round the resinously electrified or negative surface. If two separate vessels are employed to contain the solution, connected by moist asbestos, it is found that the acid collected in the vessel containing the wire positively electrified, will be in definite proportion to the matter collected in the other cup; that is, it will form with it a neutrosaline compound. If aqueous muriatic acid be acted on by the wires, hydrogen will separate at the negative surface, and chlorine at the positive.

The preceding may be regarded as the elementary and fundamental facts, discovered with regard to voltaic electricity. Before describing its greater and more complex operations, we shall give an account of the various modifications of the apparatus.

In the original trough of Cruikshanks, the contact of every pair of copper and zinc plates was secured by soldering their surfaces together. Each compound metallic plate being of a square form, was fixed tight by cement into grooves cut in the sides, and across the bottom, of the oblong mahogany box. The cells between every pair of plates, were filled with the neutrosaline or acidulous exciting liquid. The difficulty of cleaning the surfaces of the plates in this construction, and an idea that the quantity of electricity was proportional to the zinc surface exposed to oxidizement, led to the revival of the *Couronnes des tasses* arrangement. In this, the square plates of zinc and copper in each pair were placed parallel to each other, at a distance of about half an inch, and soldered together at the middle of one edge by a rectangular narrow arc of copper. Each pair was fixed parallel to the preceding pair, and at a distance corresponding to the width of the cells in the porcelain trough, by screwing their rectangular arcs to a rod of baked and well varnished wood. Ten or a dozen pairs of plates, from four to six inches diameter each, could thus at once be conveniently plunged into, or removed from, the exciting liquid. By connecting together a series of these troughs, a very powerful battery was obtained. More recently, Dr. Wollaston has rendered it probable that the igniting influence of the voltaic apparatus, is increased by placing opposite to both surfaces of the zinc, at the distance of one-eighth or one-fourth of an inch, a copper plate. At least the astonishing power of ignition, exhibited by his pair of small plates, seems to warrant that conclusion.

For compactness of structure, and convenience in use, I prefer the original mahogany box, and soldered pairs of plates, of Cruikshanks. The zinc surfaces may be easily freed from adhering oxide, by a steel scraper of a proper shape. Nor do I find that this form of apparatus is notably inferior, in chemical effect, to the separate plates of the same size in porcelain cells. Dr. Hare of Philadelphia has lately contrived an ingenious modification of Dr. Wollaston's single igniting pair, which from its great power of exciting heat, and its small electric intensity, he has styled a calorimotor.†

When the plates are very large, they must be constructed on the plan of the porcelain trough. In this way, Mr. Children arranged his gigantic battery, the most magnificent voltaic apparatus which the world has hitherto seen. It consisted of 20 pairs of copper and zinc plates, each plate six feet long and two feet eight inches broad. Each pair is joined at top by ribbons of lead, and has a separate wooden cell. They are suspended from a beam of wood, and having counterpoises, are easily raised or let down into their cells. The power of this battery was first tried on 2d of July 1813. The cells were filled with water 60 parts, and a mixture of nitric and sulphuric acids one part, which was gradually increased till the quantity of acid was doubled. Conductors of lead conveyed the electricity to an adjoining shade, in which the experiments were made. The power of the battery was prodigious. It ignited six feet in length of thick platinum wire; but could not ignite an equal length of smaller platinum wire. This difference was ingeniously ascribed by Dr. Wollaston, to the cooling influence of the air, acting more efficaciously on the slender mass of metal. Platinum, in shorter lengths, was fused with great facility. Iridium was melted into a globule, and proved to be a brittle metal. The compound ore of iridium and osmium, was likewise fused, but not perfectly. Charcoal kept at a white heat, in chlorine and chlorocarbonous gases, produced no change on them. Neither tungsten nor uranium was any way changed by this vast battery.

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† On referring to the article *Calorimotor*, it will be seen, that there is an essential difference between the action of a very large galvanic pair and a very small one. The apparatus, which I contrived, is not a modification of Wollaston's. His elementary battery and the calorimotor are opposite modifications of the original galvanic pair. Mine is the proper antipode (if I may be allowed this word) of De Luc's electric column, while neither the effects nor the size of his apparatus would justify us in thus characterizing it.

At a very early period of his illustrious electro-chemical career, Sir H. Davy invented various voltaic constructions, in which either only one metal was employed, or no metallic body at all. Among the *scientific news* inserted in the Philosophical quarto Journal for May 1801, we are told that he had formed piles, consisting of the single metals, silver, copper, zinc, and lead; and that one of the arrangement was, a plate of metal, cloth soaked in dilute nitrous acid, cloth soaked in water, and cloth soaked in solution of sulphuret of potash; then another plate of the same metal, and the three cloths as before. It is added, that if a trough be used with cells, and the separation between the acid and the sulphuret of potash be made by a plate of horn, instead of the cloth imbibed with water, the two fluids may be connected by a slip of wetted cloth, hung over the upper edge of the horn. This will complete the communication, without occasioning any mixture, because water is lighter than any of the other fluids. A full account of these new and very curious arrangements, was published in the Philosophical Transactions for the above year, and is copied into the December Number of Nicholson's Journal.

Silver or copper, in the above construction, forms an electrical apparatus, which, with a series of fifty plates, will give shocks. When the structure is that of a pile, the cloth impregnated with the densest solution should be undermost in each alternation; and solution of common salt in the middle.

The following tables contain some series, which form voltaic electrical combinations, arranged in the order of their powers; the most active substances being named first in each column.

TABLES by Sir H. Davy, of some Electrial Arrangements, which, by combination, form voltaic batteries, composed of two conductors, and one imperfect conductor.

Zinc	Each of these is the positive pole to all the metals below it, and negative with respect to the metals above it in the column.	Solutions of nitric acid.
Iron		of muriatic acid.
Tin		of sulphuric acid.
Lead		of sal ammoniac.
Copper		of nitre.
Silver		other neutral salts.
Gold		
Platinum		
Charcoal		

TABLE II.—*Of some Electrical Arrangements, consisting of one conductor and two imperfect conductors.*

Solution of sulphur and potash	Copper	Nitric acid.
of potash	Silver	Sulphuric acid.
of soda	Lead	Muriatic acid.
	Tin	Any solution containing acid.
	Zinc	
	Other metals	
	Charcoal	

The metals having the strongest attraction for oxygen, are the metals which form the positive pole, in all cases in which the fluid menstrua act chemically, by affording oxygen; but when the fluid menstrua afford sulphur to the metals, the metal having the strongest attraction for sulphur, under the existing circumstances, determines the positive pole. Thus, in a series of copper and iron, introduced into a porcelain trough, the cells of which are filled with water, or with acid solutions, the iron is positive, and the copper negative; but when the cells are filled with solutions of sulphur and potash, the copper is positive, and the iron negative.

In all combinations in which *one* metal is concerned, the surface opposite the acid is negative, while that in contact with the solution of alkali and sulphur, or of alkali, is positive.

Every one who has a perception of the beautiful in philosophical research, must regard this important law, discovered by Sir H. Davy, with admiration. It promises to lead us eventually into the mysteries of electro-chemical action, further than any general principle hitherto established. It gives another fine analogy between electricity and heat. For as the disengagement of the latter power is always proportional to the intensity of chemical combination, so in the present case we see, that the intenser chemical action is connected with the evolution of positive electricity, while the feebler is associated with the negative. The positive electricity, if we judge from the appearance of its light, is the more active of the two; and it is known to promote the most intense combinations of bodies, viz. those with chlorine, iodine, and oxygen.

The divergence of the leaves in the gold-leaf electroscope, and more exactly, the separation of the ball and disc in the electrometer of Coulomb, are proportional to the resilient force, or intensity of the electrical agent. Hence the repetition of a series of moderate sized voltaic plates, indicates the same repulsing energy on these instruments, as the same series of much larger plates. With regard to imperfect conductors, like the human body, or neutrosaline solutions, the effects, namely, the shock, and transfer of the elements, are also proportional to the electrical intensity, or electroscopic indications. For these purposes, we need not enlarge the plates beyond a certain size, which is relative to the conducting power of the substances, through which the electrical energy is to be transmitted. But with excellent conductors, like charcoal and the metals, the *quantity* of electricity, and not its state of *condensation*, is to be regarded. The intensity is essential, to enable it to communicate electrical polarities to a series of material liquid molecules, or to force its way, so to speak, through the animal frame. But the same intensity is altogether superfluous relative to metallic objects. To operate changes on these, we must favour the evolution of a great mass of electrical power, by using plates of extensive areas.

To prove the justness of these views, let us bring into action, by the same exciting liquid, a clean battery of 20 pairs of 1 inch, and 20 pairs of 10 inch plates. On exposing a small column of water, in a glass tube, first to the one battery, and then to the other, or on connecting, with the two hands, first the extremities of the one, and then those of the other, we shall perceive the evolution of gases, or the shock, to be nearly equal. While the energy of the larger battery is acting on the water or human body, let two little cylinders, of charcoal, connected with the ends of the trough by metallic wires, be made to touch each other, the electrical excess will be sufficient to produce vivid ignition at the points of contact. Silver leaf may be substituted for the charcoal, with a similar effect. The little battery, however, exhausts its energy on the column of water. When thus employed, it will give scarcely any sensation to the fingers, and produce no effect on the charcoal or leaf. Even the battery of Mr. Children, which, after igniting great lengths of platinum wire, to a whiteness insupportable to the eye, fused it into globules; and which emitted from charcoal a light more dazzling than the sunbeam, had no more effect on water, and the living body, than an equal series of little plates.

As Mr. Children's battery is the most powerful in the world, in *calorific effect*, so that of 2000 pairs of plates, of 32 inches each, furnished by the subscription of a few patrons of science connected with the Royal Institution, is the most powerful yet constructed in *electro-chemical intensity.* The whole surface is 128000 square inches.

This battery, when the cells were filled with 60 parts of water, mixed with one part of nitric acid, and one of sulphuric acid, afforded a series of brilliant and impressive effects. When pieces of charcoal, about an inch long, and one-sixth of an inch in diameter, were brought within 1-30th or 1-40th of an inch of each other, a bright spark was produced, and more than half the volume of the charcoal became ignited to whiteness; and by drawing back the points a little from each other, a constant discharge took place, through the heated air, in a space equal at least to four inches, producing a most brilliant ascending arch of light, expanded and conical in the middle. When any substance was introduced into this arch, it instantly became ignited.

Platinum melted in it, like wax in the flame of a common candle. Quartz, the sapphire, magnesia, lime, all entered into fusion. Fragments of diamond, and points of charcoal and plumbago, rapidly disappeared, and seemed to evaporate in it, even when the connexion was made in a receiver exhausted by the air-pump; but there was no evidence of their having previously undergone fusion.†

When the communication between the points, positively and negatively electrified, was made in air rarefied in the receiver of the air-pump, the distance at which the discharge took place increased as the exhaustion proceeded, and when the atmosphere in the vessel supported only an inch of mercury in the barometrical gauge, the sparks passed through a space of nearly half an inch. By making the points recede from each other, the discharge was made through 6 or 7 inches, producing a most beautiful coruscation of purple light; the charcoal became intensely ignited, and some platinum wire attached to it, fused with brilliant scintillations, and fell in large globules upon the plate of the pump. All the phenomena of chemical decomposition were produced with intense rapidity, by this combination. When the points of charcoal were brought near each other in non-conducting fluids, such as oils, ethers, and chloridic compounds, brilliant sparks occurred, and elastic matter was generated. Such, indeed, was the electric intensity, that sparks were produced, even in good imperfect conductors, such as the nitric and sulphuric acids.

When the two conductors from the ends of the combination, were connected with a Leyden battery, one with the internal, the other with the external coating, the battery instantly became charged; and on removing the wire, and making the proper connexions, either a shock or a spark could be perceived, and the least possible time of contact was sufficient to renew the charge to its full intensity.

The general facts of the connexion of the increase of the different powers of the battery with the increase of the number, and surface of the series, are very distinct; but to determine the exact ratio of the connexion, is a problem not easy of solution.

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† It is surprising to me, that the discordancy of these phenomena, with any that have been produced by mechanical electricity, should not strike every electrician. I have exposed a differential thermometer, (made with ether according to Dr. Howard's plan), to a current of electricity from a very powerful machine, without its indicating the slightest change of temperature.

Introducing the thermometer through one of the necks of a receiver, a current of electricity was made to pass from a wire to a charcoal point, for ten minutes, without any perceptible effect on the warmth of the air in the vessel. The discharge of a battery produced a momentary depression of the fluid in the stem of the thermometer; but it took place, and ceased so quickly, that I question if it were not produced by the compression of the air around the bulb, or were not a dilatation due to the rays of light simply.

It appears, therefore, that heat does not accompany a genuine electrical stream. I will venture to assert, that non-conducting bodies are never heated by it, unless in consequence of their proximity to conductors, which are heated. The appearance of such immense quantities of caloric in these experiments of Sir H. Davy, and the fusion of quartz and other non-conductors can, therefore, only be explained by supposing it, no less than the electric fluid, a product of galvanic action, and a constituent of the galvanic fluid.

Indeed, that great philosopher considers it as irreconcilable with the materiality of caloric, that a wire should be ignited for an unlimited time in vacuo. This inference does not follow, if we suppose the wire to receive caloric from the apparatus, instead of supposing it only to receive electricity. Under the article caloric, in this work, I think I have demonstrated the materiality of that principle. Those who concur in my conclusions on that subject, will, I trust, agree with me in deciding, that the unlimited ignition of a wire, in vacuo, by galvanic apparatus, proves the heat to be a concomitant product, not an effect of the electrical fluid.

The following experiment I conceive to be very unfavourable to the idea, that galvanic ignition arises from a current of electricity.

A cylinder of lead of about a quarter of an inch diameter, and about two inches long, was reduced to the thickness of a common brass pin for about three quarters of an inch. When one end was connected with one pole of the deflagrator, the other remained suspended by this filament; yet it was instantaneously fused by contact with the other pole. As all the calorific fluid which acted upon the suspended knob, must have passed through the filament by which it hung, the fusion could not have resulted from a pure electrical current, which would have dispersed the filament, as I have ascertained by trial, ere a mass, fifty times larger, had been perceptibly affected.

See passage subjoined by me to this article; also Galvanic Deflagrator.

MM. Gay-Lussac and Thenard announced, that the power of chemical decomposition increases only as the cube root of the number of plates; but their experiments were made with parts of piles, says Sir H. Davy, very unfavourable for gaining accurate results. In various trials made by him, with great care, in the laboratory of the Royal Institution, the results were altogether different.

The batteries employed were parts of the above great combination, carefully insulated, and similarly charged; arcs of zinc and silver presenting equal surfaces, arranged in equal glasses, filled with the same kind of fluid, were likewise used; and the tubes were precisely similar, and filled with the same solution of potash. In these experiments, 10 pairs of plates produced 15 measures of gas; 20 pairs produced in the same time 49; again, 10 pairs produced five measures; 40 pairs in the same time produced 78 measures. In experiments made with arcs, and which seemed unexceptionable,

4 pairs produced 1 measure of gas.
12 in the same time $9\frac{7}{10}$
When 6 produced 1
30 - - 24.5

Now, these quantities are nearly as the squares of the number of pairs.

In batteries, whose plates have equal areas, the calorific power has been said to be as the number. Sir H. Davy, however, found that when the surface of each was 100 square inches,

10 pairs ignited 2 inches of plat. wire 1-80th of an inch.
20 do. do. 5 inches do. do.
40 do. do. 11 inches do. do.

The results of experiments on higher numbers were not satisfactory; for 100 pairs, of 32 square inches each, ignited three inches of platinum wire 1-70th of an inch; and 1000 ignited only 13 inches. The charges of exciting acid, were similar in both cases.

The ratio between the increase of calorific power, and increased area of the plates, is probably greater than even the square. For 20 pairs of plates, containing each two square feet, did not ignite one-sixteenth as much wire, as 20 pairs, containing each eight square feet; the acid employed being of the same strength in both cases. But great difficulties occur to ensure accuracy, in experiments on extensive and powerful batteries.

In Sir H. Davy's great Bakerian Lecture on the chemical agencies of electricity, published in the Phil. Trans. for 1807, and most deservedly crowned by the National Institute of France with the Napoleon prize, he amply demonstrated that acids, which are electrically negative, with respect to alkalis, metals, and earths, are separated from these bodies in the voltaic circuit at the positive pole; and alkalis, metals, and earths, are separated from acids, at the negative surface. He showed further, that such are the attracting powers of these surfaces, that acids are transferred through alkaline solutions, and alkalis through acid solutions, to the poles where they have their points of repose. This was exhibited by making a combination of three agate cups, one containing sulphate of potash, one weak nitric acid, and the third distilled water. The three were connected by asbestus moistened in pure water, in such a manner, that the surface of the acid was lower than the surface of the fluid, in the other two cups. When two wires of platina from a powerful voltaic apparatus, are introduced into the two extreme cups, the solution of the salt being positively electrified, a decomposition took place, and in a certain time, a portion of potash was found dissolved in the cup, in contact with the negative wire, though the fluid in the middle cup was still sensibly acid.

Such are the chemico-analytical powers of electricity, that not even insoluble compounds are capable of resisting their energy; for even glass, sulphate of barytes, fluor spar, gypsum, marble, &c. when moistened and placed in contact with electrified surfaces, from the voltaic apparatus, are sensibly acted on, and the alkaline, earthy, or acid matter, slowly carried to the poles in the common order. Not even the most solid aggregates, nor the firmest compounds, are capable of resisting this mode of attack. Its operation is slow, but the results are certain, and, sooner or later, by means of it, bodies are resolved into simpler forms of matter.

Till Sir H. Davy established the grand law of electro-chemical decomposition, that metals, inflammable bodies, alkalis, earths, and oxides, are determined to the negative surface or pole, and oxygen, chlorine, iodine, and acids, to the positive pole, it had been imagined that various substances might be generated from pure water, by means of electricity, such as potash, soda, and muriatic acid. A strict investigation of the circumstances under which these substances appeared, led him to discover that they were always furnished from the vessels, or from impurities in the water, and enabled him to determine the general principles of electrical decomposition, and to apply this power to the resolution of several species of matter of unknown nature into their elements, namely the alkalis, earths, boracic and muriatic acids, &c.

The intimate relation between the electrical and chemical changes, is evident likewise in the general phenomena of the battery. The most powerful voltaic combinations are formed by substances that act chemically, with most energy upon each other. Such substances as undergo no chemical changes in these combinations, exhibit no electrical powers. Thus, zinc, copper and nitric acid, form a powerful battery; while silver, gold, and water, which do not act chemically on each other, produce, in series of the same number, no perceptible effect. These circumstances, in the infancy of galvanic research, led to the belief that the electrical phenomena were entirely the results of chemical changes; and that as heat was produced by chemical action, under common circumstances, so electricity resulted from it under other circumstances.

This generalization seems, however, to be incorrect. Zinc and copper, different metals and oxalic acid, different metals and sulphur or charcoal, exhibit electrical effects after mere contact, and that in cases when not the slightest chemical change can be observed. If, in these experiments, indeed, chemical phenomena are produced by the action of menstrua, all electrical effects immediately cease.

The source of action of the voltaic apparatus, seems to depend upon causes similar to those which produce the accumulation in the Leyden battery; namely, that influence at a distance, or electrical induction, which was fully treated of at the commencement of this article. But its continuous action, or electro-motion, is connected with the decomposition of the chemical menstrua between the plates. Each plate of zinc, in the first place, is made positive, and each plate of copper negative, by contact; and all the plates are so arranged with respect to each other, as to have their electricities exalted by induction, so that every single polar arrangement heightens the electricity of every other polar arrangement; and hence the accumulation of power, or intensity, must increase with the number of the series. When the battery is connected in a circle, the effects are demonstrated by its constant exhibition of chemical agencies, and the powers exist as long as there is any menstruum to decompose. But when it is insulated, and the extreme poles of zinc and copper are unconnected, no effects whatever are perceived to take place, no chemical changes go on, and it exhibits its influence only by communicating very weak charges to the electrometer; the zinc termination of the pole communicating a positive charge, the copper termination a negative charge.

A beautiful experiment of Sir H. Davy's proves, that each plate of the most oxidable metal in the apparatus, is in the relation of positive, and that each plate of the least oxidable, is in the relation of negative, while every series is possessed of similar and equal polarity. Forty rods of zinc of the same size, connected with forty silver wires, precisely similar, were introduced in the regular order into similar glasses, filled with a solution of muriate of ammonia, rendered slightly acidulous by muriatic acid. As long as the extreme parts remained unconnected; no gas was disengaged from the silver, and the zinc was scarcely acted upon. When they were connected, all the plates of zinc were dissolved much more rapidly, and hydrogen gas was evolved from every silver wire. In another experiment, in which several of these wires, at equal distances, were introduced into small glass tubes, it was found that equal quantities of hydrogen were produced.

There are no fluids known, except such as contain water, which are capable of being made the medium of connexion between the metals or metal of the voltaic apparatus; and it is probable that the power of water to receive double polarities, and to evolve oxygen and hydrogen, is necessary to the constant operation of the connected apparatus. We may suppose also, that acids or saline bodies increase the action, by affording elements which possess opposite electricities to each other, when mutually excited. The action of the chemical menstrua exposes continually new surfaces of metal; and the electrical equilibrium may be conceived, in consequence, to be alternately destroyed and restored, the changes taking place in imperceptible portions of time.

We may show the manner in which aqueous fluids propagate electrical polarity among their particles, by a very simple experiment. Cut narrow filaments of tin-foil into lengths of almost half an inch, and place them in a line in the surface of an oblong trough of water. On plunging into the water, at each end, wires connected with the two extremities of an active voltaic battery, the metallic filaments will immediately acquire polarity. Their positive and negative poles will become regularly opposed to each other, the first depositing oxide, and the last evolving hydrogen. The analogy with magnetic actions, is here very complete.

That the decomposition of the chemical agents is connected with the energies of the pile, is evident from all the experiments that have been made. No sound objection has been urged against the theory, that the contact of the metals destroys the electrical equilibrium, and that the chemical changes restore it; and, consequently, that the action exists as long as the decompositions continue.

Volta called his admirable invention an electro-motive apparatus, founding his theory of its operation upon the Franklinian idea of an electrical fluid, for which certain bodies have stronger attractions than others. He conceived that in his pile, the upper plate of zinc attracts the electricity from the copper, the copper from the water, the water again from the next plate of zinc, the next plate of zinc from the next plate of copper, and so on.[†1] This hypothesis applies happily to most of the phenomena of the action of the insulated pile, and the pile connected by either of its extremities with the ground; but does not explain with the same facility, the powers of the apparatus connected in a circle, in which each plate of zinc must be supposed to have the same quantity of electricity as each plate of copper; for it can only, as Sir H. Davy justly observes, receive as much as the copper can give, unless indeed the phenomena of the circular apparatus be considered as depending upon the constant and rapid circulation of the natural quantity of electricity in the different series, which requires the proof of a constant power to attract electricity from one body, at the same time that it is given off to another. But the investigations of Coulomb and Poisson, already detailed, fully demonstrate that electricity is not distributed among different species of matter, by any kind of elective attraction.

Platinum melts with more facility at the positive than at the negative pole, when it is connected with charcoal; but with sulphuric acid, it becomes red-hot, only when it is negative, and the acid positive. In the calorific effect in general, charcoal is most easily ignited, next iron, platinum, gold, then copper, and lastly, zinc.

See Sir H. Davy's Elements, and M. Biot's Traité de Physique, tome ii. chapitre 16; *Effects chimiques de l'Appareil electromoteur.**

† I conceive that the galvanic fluid owes its properties to caloric and electricity; the former predominating in proportion to the size of the pairs, the latter in proportion to the number, being in both cases excited by a powerful acid. Hence in batteries, which combine both qualifications sufficiently, as in all those intervening between Children's large pairs of two feet eight inches by six feet, and the 2000 four-inch pairs of the Royal Institution, the phenomena indicate the presence of both fluids. In De Luc's column, where the size of the pairs is insignificant, and the energy of interposed agents feeble, we see electricity evolved without any appreciable quantity of caloric. In the calorimotor, where we have size only, the number being the lowest possible, we are scarcely able to detect the presence of electricity.

When the fluid contains enough electricity to give a projectile power, adequate to pass through a small space in the air, or through charcoal, which impedes or arrests the caloric, and favours its propensity to radiate, this principle is evolved. This accounts for the evolution of intense heat, under those circumstances, which rarefies the air, so that the length of the jet from one pole to the other may be extended after its commencement. Hence the portions of the circuit nearest to the intervening charcoal or heated space, are alone injured; and even non-conducting bodies, as quartz, introduced into it are fused; and hence a very large wire may be melted by the fluid, received through a small wire imperceptibly affected.

See my memoirs on the Calorimotor & Galvanic Deflagrator in Silliman's Journal.†

* We shall retain the title GALVANISM, out of respect to its illustrious discoverer, and place under it, some details concerning the influence of this form of electricity on living bodies.* † See GALVANIC DEFLAGRATOR.†

* ELECTRUM. See ORES of GOLD.*

ELEMENTS. A term used by the earlier chemists, nearly in the same sense as the moderns use the term *first principle.* The chief, and indeed very essential difference between them is, that the ancients considered their elements as bodies possessing absolute simplicity, and capable of forming all other bodies by their mutual combination; whereas the first principles of the moderns are considered as simple, merely in respect to the present state of the art of analyzing bodies.

* ELEMI. A resin, which exudes from incisions made, in dry weather, through the bark of the *amyris elemifera,* a tree which grows in America. It is wrapped in flag leaves, in long roundish cakes, semi-transparent, and of a yellow colour. It has a faint fragrance.*

ELIQUATION. An operation, by means of which a more fusible substance is separated from another which is less fusible. It consists in the application of a degree of heat sufficient to fuse the former, but not the latter.

ELUTRIATION. This word is used by chemists to denote the process of washing, which carries off the lighter earthy parts, while the heavier metallic parts subside to the bottom.

[†1] If the zinc attract electricity from the copper, it has a stronger affinity for electricity. The water attracts electricity from the zinc; it has then a stronger affinity for it than zinc; and *a fortiori* stronger than copper, whose affinity is weaker than that of zinc. Copper cannot then attract electricity from water by the premises.

* **Emerald.** This genus contains two species, the prismatic and rhomboidal.

1. *Prismatic Emerald*, Euclase of Haüy. Its colours are green, of various shades, and sometimes sky-blue. It is found only crystallized. The primitive form is a prism of 133° 24′. Its secondary forms are, an oblique four-sided prism, variously modified by accuminations and truncations. The lateral planes are more or less longitudinally streaked, giving the prisms a reed-like appearance. Lustre splendent. Cleavage perfect, in the direction of the smaller diagonals of the prism. Fracture small conchoidal. Fragments tabular. Transparent. Refracts double. Harder than quartz, but softer than topaz. Easily frangible. Sp. gr. 2.9 to 3.3. Loses transparency, and then melts before the blow-pipe. Its constituents are 35 to 36 silica, 18 to 19 alumina, 14 to 15 glucina, 2 to 3 iron, and 27 to 31 loss. The last is chiefly water, and in some measure alkali. Found in Peru and Brazil. It is a beautiful mineral, but too brittle for jewelry.

2. *Rhomboidal Emerald*, of which there are two sub-species, the precious emerald and the beryl. Precious emerald is well characterized by its emerald-green colour, of various depths. It is generally crystallized. The primitive form is an equiangular six-sided prism, on which various truncations are found. The lateral planes are smooth; the terminal planes rough. Lustre splendent. Cleavage straight and four-fold. Fracture imperfect conchoidal. Transparent. Moderate double refraction. Nearly as hard as topaz. Sp. gr. 2.6 to 2.77. Heated to a moderate degree, it becomes of a blue colour, but recovers its tint on cooling. At a high heat, it fuses into a white vesicular glass. Its constituents are, silica 64.5, alumina 16, glucina 13, oxide of chrome 3.25, lime 1.6, water 2. Klaproth found 1. of oxide of iron. It occurs in drusy cavities, along with iron pyrites, calcareous spar, and quartz, in veins that traverse clay-slate. The most beautiful emeralds come from Peru. As a gem, it is valued next to the ruby. See **Beryl**, in its alphabetical place.*

* **Emery.** A sub-species of rhomboidal corundum. Its colour is intermediate between grayish-black, and bluish-gray. It occurs massive and disseminated, and also in granular concretions. Lustre glistening and adamantine. Fracture fine grained uneven. Translucent on the edges. So very hard as to scratch topaz. Difficultly frangible. Sp. gr. 4.0. Its constituents are 86 alumina, 3 silica, 4 iron, and 7 loss. In Saxony, it occurs in beds of talc and steatite. It occurs abundantly in the Isle of Naxos, and also at Smyrna. It is used for polishing hard minerals and metals. Its fine powder is obtained by trituration and elutriation.*

* **Emetin.** Digest ipecacuan root, first in ether and then in alcohol. Evaporate the alcoholic infusion to dryness, redissolve in water, and drop in acetate of lead. Wash the precipitate, and then diffusing it in water, decompose by a current of sulphuretted hydrogen gas. Sulphuret of lead falls to the bottom, and the emetin remains in solution. By evaporating the water, this substance is obtained pure.

Emetin forms transparent brownish-red scales. It has no smell, but a bitter acrid taste. At a heat somewhat above that of boiling water, it is resolved into carbonic acid, oil and vinegar. It affords no ammonia. It is soluble both in water and alcohol, but not in ether; and uncrystallizable. It is precipitated by proto-nitrate of mercury and corrosive sublimate, but not by tartar emetic. Half a grain of emetin acts as a powerful emetic, followed by sleep; six grains vomit violently, and produce stupor and death. The lungs and intestines are inflamed. Pelletier and Magendie, *Ann. de Chimie et Physique*, iv. 172.*

Empyreuma. This term is applied to denote the peculiar smell produced by a considerable heat upon vegetable or animal substances in closed vessels, or when burned under circumstances which prevent the access of air to a considerable part of the mass, and consequently occasion an imperfect combustion, or destructive distillation of the parts so covered up by the rest of the mass.

Emulsion. An imperfect combination of oil and water, by the intervention of some other substance capable of combining with both these substances. The substances are either saccharine or mucilaginous.

Enamel. There are two kinds of enamel, the opaque and the transparent. Transparent enamels are usually rendered opaque by adding putty, or the white oxide of tin, to them. The basis of all enamels is therefore a perfectly transparent and fusible glass. The oxide of tin renders this of a beautiful white, the perfection of which is greater when a small quantity of manganese is likewise added. If the oxide of tin be not sufficient to destroy the transparency of the mixture, it produces a semi-opaque glass, resembling the opal.

Yellow enamel is formed by the addition of oxide of lead, or antimony. Kunckel likewise affirms, that a beautiful yellow may be obtained from silver.

Red enamel is afforded by the oxide of gold, and also by that of iron. The former is the most beautiful, and stands the fire very well, which the latter does not.

Oxide of copper affords a green; manganese, a violet; cobalt, a blue, and iron, a very fine black. A mixture of these different enamels produces a great variety of intermediate colours, according to their nature and proportion. In this branch of the art, the coloured enamels are sometimes mixed with each other, and sometimes the oxides are mixed before they are added to the vitreous bases.

* In the transactions of the Society of Arts for 1817, a valuable list of receipts for enamel colours is given by Mr. R. Wynn, for the communication of which a premium was awarded. The following are Mr. Wynn's fluxes:—

No. 1.	Red lead,	8 parts.
	Calcined borax;	1½
	Flint powder,	2
	Flint glass,	6
No. 2.	Flint glass,	10
	White arsenic,	1
	Nitre,	1
No. 3.	Red lead,	1
	Flint glass,	3
No. 4.	Red lead,	9½
	Borax not calcined,	5½
	Flint glass,	8
No. 5.	Flint glass,	6
	Flux, No. 2.	4
	Red lead,	8

After the fluxes have been melted, they should be poured on a flag stone, wet with a sponge; or into a large pan of clean water, then dried, and finely pounded in a biscuit-ware mortar for use.

Yellow enamel.	
Red lead,	8
Oxide of antimony,	1
White oxide of tin,	1

Mix the ingredients well in a biscuit-ware mortar, and having put them on a piece of Dutch tile in the muffle, make it gradually red-hot, and suffer it to cool. Take of this mixture 1, of flux No. 4. 1½; grind them in water for use. By varying the proportions of red lead and antimony, different shades of colour may be obtained.

Orange.	
Red lead,	12
Red sulphate of iron,	1
Oxide of antimony,	4
Flint powder,	3

After calcining these without melting, fuse 1 part of the compound with 2½ of flux.

Dark red.	
Sulphate of iron calcined dark,	1
Flux, No. 4. 6 parts Colcothar, 1 } of this	3
Light red.	
Red sulphate of iron,	1
Flux, No. 1,	3
White lead,	1½
Brown.	
Manganese,	2¼
Red lead,	8½
Flint powder,	4

See transactions of the Society, or the Phil. Mag. vol. 51. Mr. Tilloch justly observes, that borax should be used sparingly, as it causes efflorescence, and decay of the enamel colours.*

Entrochi. A genus of extraneous fossils, usually of about an inch in length, and made up of a number of round joints, which when separate and loose, are called trochitæ: they are composed of the same kind of plated spar with the fossil shells of the echini, which is usually of a bluish-gray colour, and are very bright where fresh broken; they are all striated from the centre to the circumference, and have a cavity in the middle. They seem to be the petrified arms of that singular species of the sea star-fish, called Stella arborescens.

***Epidote.** Pistacite.—*Werner*. A subspecies of prismatoidal augite.—*Jameson*.—Acanticone, from Norway. Colours, pistachio green, and green of darker shades. Massive, in distinct granular or fibrous concretions, and crystallized. The primitive form is an oblique four-sided prism, in which the lateral planes meet at angles of 114° 37′ and 65° 23′. The secondary forms are, 1. Very oblique four-sided prisms, bevelled on the extremities. 2. That figure truncated on the acute edges, and flatly bevelled on the extremities. 3. A broad unequiangular six-sided prism, variously acuminated or truncated. 4. A very oblique four-sided prism, truncated on the obtuse lateral edges, and doubly acuminated on the extremities by four planes. The crystals are sometimes reed-like, and the lateral planes are longitudinally streaked; but the truncating, acuminating, and bevelling planes, are smooth, and the terminal planes diagonally streaked. Lustre splendent, internally inclining to pearly. Cleavage twofold. Fracture flat conchoidal. Translucent. Harder than feldspar, but not so hard as quartz. Brittle.—Sp. gr. 3.45. Before the blow-pipe, it is converted into a brown coloured scoria, which becomes black with heat. Its constituents are silica 37, alumina 21, lime 15, oxide of iron 24, oxide of manganese 1.5, water 1.5. Laugier found 26 alumina, 20 lime, and 13 oxide of iron. It occurs in primitive beds and veins, along with augite, garnet, hornblende, calcareous spar, copper pyrites, &c. It is found in Arran, in secondary syenite and clay-slate; in Mainland of Shetland, in syenite; in the Island of Icolmkill, in a rock composed of red feldspar and quartz; in the syenite of Glencoe; in similar rocks among the Malvern hills; in quartz, at Wallow Crag, near Keswick; in Cornwall; Arendal, in Norway; in Bavaria, France, &c.*

Epidermis. If the human skin be macerated in hot water, it separates into two parts, the *cutis*, or true skin, and the *epidermis*, or scarf skin. The continued action of warm water at length dissolves the cutis, but does not affect the epidermis, neither does alcohol. Caustic alkali, however, dissolves it. It resembles coagulated albumen.

Epsom Salt. Sulphate of magnesia.

* **Equivalents (Chemical).** A term happily introduced into chemistry by Dr. Wollaston, to express the system of definite ratios, in which the corpuscular subjects of this science reciprocally combine, referred to a common standard, reckoned unity. If, with this profound philosopher, we assume oxygen as the standard, from its almost universal relations to chemical matter; then calling it unity, we shall have, in the following examples, these ratios reduced to their lowest terms, in which the equivalents will be Prime ratios:—

The lowest ratio, or equivalent prime of oxygen being	1.000
That of hydrogen will be	0.125
Of fluor ?	0.375
Of carbon,	0.750
Of phosphorus,	1.500
Of azote,	1.750
Of sulphur,	2.000
Of calcium,	2.550
Of sodium,	2.950
Of potassium,	4.950
Of copper,	8.00
Of barium,	8.75
Of lead,	13.00, &c.

The substances in the above table, susceptible of reciprocal saturation, can combine with oxygen or with each other, not only in proportions corresponding to these numbers, but also frequently in multiple or sub-multiple proportions. We have therefore two distinct propositions on this interesting subject.

1st, The general reciprocity of the saturating proportions.

2d, The multiple and submultiple proportions of prime equivalents, in which any one body may unite with any other body, to constitute successive binary compounds.

The first proposition, or grand law of chemical combination, was discovered by J. B. Richter of Berlin, about the year 1792. The second, of equal importance, and more recondite, was discovered so early as the year 1790, by Mr. W. Higgins.

Richter inferred his from the remarkable and well established fact, that two neutral salts, in reciprocally decomposing each other, give birth to two new saline compounds, always perfectly neutral. Thus, sulphate of soda being added to muriate of lime, will produce perfectly neutral sulphate of lime and muriate of soda. The conclusions he drew were, 1st, That the quantities of two alkaline bases, adequate to neutralize equal weights of any one acid, are proportional to the quantites of the same bases, requisite to neutralize the same weights of every other acid. For example, 6 parts of potash, or 4 of soda, neutralize 5 of sulphuric acid; and 4.4 of potash are adequate to the saturation of 5 of nitric acid. Therefore, to find the quantity of *soda* equivalent to the saturation of this weight of nitric acid, we need not make experiments, but merely compute it by the proportional rule of Richter. Thus, as 6 : 4.4 : : 4 : 2.93; or in words, as the potash equivalent to the sulphuric acid, is to the potash equivalent to the nitric acid, so is the soda equivalent to the first, to the soda equivalent to the second. And again, if 6.5 potash saturate 5 of muriatic acid gas, how much soda, by Richter's rule, will be required for the same effect. We say 6 : 6.5 : : 4 : 4.3. 3dly, If 10.9 potash combine with 5 of carbonic acid, how much soda will be equivalent to that effect. Now, 6 : 10.9 : : 4 : [illegible] Here, therefore, we have found, that if 6 potash be equivalent to 4 soda, in saturating 5 of sulphuric acid, this ratio of 6 to 4, or 3 to 2, will pervade all the possible saline combinations; so that whatever be the quantity of potash requisite to saturate 5, 10, &c. of any other acid, two-thirds of that quantity of soda will suffice.

In the same manner let us find out, for five of sulphuric, or of any one standard acid, the saturating quantity of ammonia, magnesia, lime, strontites, barytes, peroxide of copper, and the other bases; then their proportions to potash, thus ascertained, for this acid, will, by arithmetical reduction, give their saturating quantity of every other acid, whose relation to potash, or indeed to any one of these bases, is known.

The experimental verification of this most important law, occupied Richter from the year 1791 to the year 1802, in which period he published, in successive parts, a curious work, entitled the Geometry of the Chemical Elements, or Principles of Stechiometry. We might have expected greater accuracy in his investigations, from the circumstance, that Dr. Wollaston selected his statement of the constituents of nitre, in preference to those of all other chemists, in the construction of his admirable table of chemical proportions.

With indefatigable zeal Richter examined, by experiment, each acid, in its relation to the bases, and then compared the results with those given by calculation, presenting both in an extensive series of tables.

It is curious that he does not seem to have been aware, that all his tables might have been reduced into a single one, of 21 numbers, divided into two columns, by means of which, every question relating to the included articles, might be solved by the rule of three, or a sliding scale. The following table, computed by Fischer from Richter's last tables, was inserted by the celebrated Berthollet in a note to his chemical statics.

Bases.		Oxygen = 1.	Acids.		Oxygen = 1.
Alumina,	525	2.625	Fluoric,	427	2.135
Magnesia,	615	3.075	Carbonic,	577	2.885
Ammonia,	672	3.36	Sebacic,	706	3.530
Lime,	793	3.965	Muriatic	712	3.560
Soda,	859	4.245	Oxalic,	755	3.775
Strontian,	1329	6.645	Phosphoric,	979	4.895
Potash,	1605	8.025	Formic,	988	4.94
Barytes,	2222	1.111	Sulphuric,	1000	5.000
			Succinic,	1209	6.045
			Nitric,	1405	7.025
			Acetic,	1480	7.400
			Citric,	1683	8.415
			Tartareous,	1694	8.470

I have added the two columns under oxygen, from which we see at once, that with the exception of the bases lime, strontian, and soda, and the acids carbonic, muriatic, sulphuric, nitric, citric, and tartaric; the numbers given by Richter do not form tolerable approximations to the true proportions. The object of the above table was, to give directly the quantities of acid and alkali requisite for mutual saturation. For example, 1605, opposite to potash, is the quantity of that alkali equivalent to neutralize 427 of fluoric acid, 577 carbonic, 712 muriatic, 1000 sulphuric, &c. Each column affords also progressively increasing numbers. Those nearest the top have the greatest acid or alkaline energies, as measured by their powers of saturation. The column of Richter gives, therefore, as far as the analytical means of his time permitted, a table of the relative weights of what has since been hypothetically called *the atoms*.

2. But two chemical constituents frequently unite in different proportions, forming distinct and often dissimilar compounds. Thus, oxygen and azote constitute in one proportion, nitrous oxide, the intoxicating gas of Sir H. Davy; in a second proportion, nitric oxide, the nitrous gas of Priestley; in a third proportion, nitrous acid; and in a fourth proportion, nitric acid. Is there any law regulating these various compounds; so that knowing the first proportion, we may infer the whole series? This question was first answered in a work containing many curious anticipations of discoveries, to which posterior writers have laid claim; I mean Mr. Higgins's Comparative View of the Phlogistic and Antiphlogistic Theory, printed in 1788, and published early in 1789. Besides some additional facts, decisively hostile to the hypothesis of phlogiston, this publication distinctly advances the doctrine of multiple proportion, with regard to the successive compounds of the same constituents. This was likewise interwoven, with new and ingenious views concerning gaseous and atomical combination. Mr. Higgins having felt himself aggrieved at seeing discoveries clearly announced by him in 1789, brought forward nineteen years afterwards by Mr. Dalton, in his own name, published in 1814 a book, entitled experiments and Observations on the Atomic Theory and Electrical Phenomena. In this work he gives numerous quotations from his *Comparative View*, which abundantly establish his claim of priority to the discovery of multiple proportions, and the atomic theory of chemistry. It is no fault of Mr. Higgins, that his first work partook of the imperfect analyses of the day. Indeed we have reason, on the contrary, to be surprised at his rejection of many errors then sanctioned by high authority, and his promulgation of many new truths, which might appear, to contemporary writers, insulated, or of little consequence, but to which subsequent researches have given a due place and importance in the system of chemical knowledge. Who would deny to Columbus the glory of discovering a new world, merely because the means of research placed within his power, did not permit him to explore its extensive coasts? Is not that glory on the contrary greatly enhanced, by the very early period at which the discovery was achieved, while navigation as a science was still unknown? I shall quote a few passages, as he gives them, from his Comparative View, which I think are decisive in this fundamental discussion.

"Hepatic gas (sulphuretted hydrogen), as shall be shown, is hydrogen in its full extent, holding sulphur in solution." This fact, of hydrogen not changing its volume, by combining with sulphur, has been marked among the valuable discoveries of later times.

"Therefore, 100 grains of sulphur, require only 100 or 102 of the dry gravitating matter of oxygen gas, to form sulphurous acid. As sulphurous acid gas is very little more than double the specific gravity of oxygen gas, we may conclude, that the ultimate particles of sulphur and oxygen contain the same quantity of matter; for oxygen gas suffers no considerable diminution of its bulk, by uniting to the quantity of sulphur necessary for the formation of sulphurous acid. It contracts 1-11th as shall be shown hereafter." Compare with the above statement, the following from Dr. Thomson's System, published in 1807. "If this analysis be precise, it follows, that 100 cubic inches of hydrogen gas, in order to be converted into sulphuretted hydrogen, combine with 7.69 grains of sulphur, and are converted into about 26.6 cubic inches; so that hydrogen gas, by dissolving sulphur, is reduced to little more than one-fourth of its original bulk." Vol. i. p. 92. Sir H. Davy has since proved, by accurate experiments, that hydrogen, in its conversion into sulphuretted hydrogen, does *not* change its bulk, agreeably to Mr. Higgins's early enunciation. "But as we know the constituents of sulphuric acid, it is easy thence to deduce the following as the proportion of the ingredients of sulphurous acid:—

68 sulphur,
32 oxygen.
—
100"

System of Chemistry, 1807, vol. ii. p. 179. The last is the result of Dr. Thomson's own experiments. Its true composition is now known to be 100 of the gravitating matter of oxygen to 100 of sulphur, in conformity with Mr. Higgins.

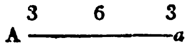
The elementary proposition of Mr. Dalton's atomical hypothesis, seems to be most explicitly announced in the following paragraph of Mr. Higgins.

"As two cubic inches of hydrogen gas require but one cubic inch of oxygen gas to condense them to water, we may presume, that they contain an equal number of divisions, and that the difference of the specific gravity of those gases depends on the size of their respective particles; or we must suppose, that an ultimate particle of hydrogen requires two or three or more particles of oxygen to saturate it. Were this the case, water, or its constituents, might be obtained in an intermediate state of combination, like those of sulphur and oxygen, or azote and oxygen, &c. This appears to be impossible; for in whatever proportion we mix hydrogen or oxygen gases, or under whatever circumstances we unite them, the result is invariably the same. Water is formed, and the surplus of either of the gases is left behind unchanged,"—"From these circumstances, we have sufficient reason to conclude, that water is composed of a single ultimate particle of oxygen, and an ultimate particle of hydrogen, and that its atoms are incapable of uniting to a third particle of either of its constituents."

Mr. Higgins inculcates very strongly, that when a body is capable of combining with another in two proportions, the third particle introduced is held by a much weaker affinity than that which unites the particles of the first or true binary compound.

"In my opinion, the most perfect nitrous acid contains 5 of oxygen and 1 of azote.—Nitrous gas, according to Kirwan, contains 2 volumes of oxygen gas, and 1 of azotic gas. According to Lavoisier, 100 grains of nitrous gas contain 32 grains of azote, and 68 of oxygen. I am of the former philosopher's opinion. I also am of opinion, that every primary particle of azote is united to 2 of oxygen, and that the molecule thus formed, is surrounded with one common atmosphere of caloric.

"As this requires demonstration, let A in the annexed diagram represent an ultimate particle of azote, which attracts oxygen with the force of 3;



Let *a* be a particle of oxygen, whose attraction to A we will suppose to be 3 more; hence they will unite with the force of 6; the nature of this compound will be hereafter explained. Let us consider this to be the utmost force of attraction that can subsist between oxygen and azote. We will now suppose a second particle of oxygen *b* to combine with A; they will only unite with the force of 4½." "This I consider to be the real structure of a molecule of nitrous gas. Let a third particle of oxygen *c* unite to A. it will combine only with the force of 4. This is the state of the red molecules of nitrous vapour, or when condensed, the red nitrous acid." "We will suppose a fourth particle of oxygen *d* to combine with A; it will unite with the force of 3¼, and so on with the rest of the particles of oxygen as the diagram represents. This I consider to be the state of a molecule of the pale or straw-coloured nitrous acid.

"When a fifth particle of oxygen *e* unites, the force of union existing between the particles of the molecule is still diminished as is represented by the diagram. The fractions show that the chemical attraction of azote for oxygen is nearly exhausted. This is the state of colourless nitrous acid; and, in my opinion, no more oxygen can unite to the azote, having its whole force of attraction expended in the particles *a*, *b*, *c*, *d*, *e*. This illustrates the nature of saturation or definite proportions."

"We can readily perceive from the foregoing demonstrations, that oxygen is retained with less force in the colourless nitrous acid than in the straw-coloured; and the latter acid retains it with less force than the red nitrous acid; and nitrous gas holds it with still more force than the red nitrous acid. This accounts for the separation of oxygen gas from the colourless nitrous acid (nitric acid) when exposed to the sun, at the same time that the acid becomes coloured. Nitrous acid in any other state will afford no oxygen, when exposed to the sun."

"Why the gaseous oxide should be more soluble in water than the nitrous gas, is what I cannot account for, unless it be occasioned by the smaller size of its calorific atmospheres, which may admit its atoms to come within the gravitating influence of that fluid."

It is impossible to deny the praise of singular ingenuity, and justness, to the above passages; and every one must be struck with their analogy, both as to atomical doctrines, and the calorific atmospheres of gases, single and compound, with the language and views expanded at full length in Mr. Dalton's new system of Chemical Philosophy, first framed about the year 1803, and published in 1808. It appears that this philosopher, after meditating on the definite proportions, in which oxygen was shown by M. Proust to exist in the two oxides of the same metal, on the successive combinations of oxygen and azote, and the proportions of various other chemical compounds, was finally led to conclude, that the uniformity which obtains in corpuscular combinations, results from the circumstance, that they consist of one atom of the one constituent, united generally with one atom of the other, or with two or three atoms. And he further inferred, that the relative weights of these ultimate atoms might be ascertained from the proportion of the two constituents in a neutral compound.

Chemistry is unquestionably under great obligations to Mr. Dalton, for the pains with which he collated the various analyses of chemical bodies, by different investigators; and for establishing, in opposition to the doctrine of indefinite affinity, taught by the illustrious Berthollet, that the different compounds of the same principles did not pass into each other by imperceptible gradations, but proceeded, *per saltum*, in successive proportions, each a multiple of the first. By correcting and extending Richter's scale of reciprocal saturation, and reviving Mr. Higgins's long neglected discovery of multiple proportion, Mr. Dalton has been no mean contributor to the advancement of the science. It is difficult to say how far his figured groups of spherical atoms have been beneficial or not. They may have had some use in aiding the conception of learners, and perhaps in giving a novel and imposing air to the atomical fabric. But their arrangement, and even their existence, are altogether hypothetical, and therefore ought to have no place in physical demonstrations.

That water is a compound of an atom of oxygen and an atom of hydrogen, is assumed by Mr. Dalton as the basis of his system. But two volumes of hydrogen here combine with one of oxygen. He therefore infers, that an atom of hydrogen occupies double the bulk, in its gaseous state, of an atom of oxygen. These assumptions are obviously gratuitous. I agree with Dr. Prout in thinking that Sir H. Davy has taken a more philosophical view of this subject. Guided by the strict logic of chemistry, he places no hypothesis at the foundation of his fabric.

Experiment shows, 1st, That in equal volumes, oxygen weigh 16 times more than hydrogen; and 2dly, That water is formed by the union of one volume of the former, and two volumes of the latter gas, or by weight of 8 to 1. We are not in the least authorized to infer from this that an atom of oxygen weighs 8 times as much as an atom of hydrogen. For aught we know, water may be a compound of 2 atoms of hydrogen, and 1 of oxygen; in which case we should have the proportion of the weights of the atoms, as given by equal volumes, namely, 1 to 16. There is no good reason for fixing on one compound of hydrogen, more than on another, in the determination of the basis of the equivalent scale. If we deliberate on that combination of hydrogen in which its agency is apparently most energetic, namely, that with chlorine, we would surely never think of pitching on *two* volumes as its *unity* or least proportion of combination; for it is *one* volume of hydrogen which unites with one volume of chlorine, producing two volumes of muriatic gas. Here, therefore, we see that *one* volume of hydrogen is quite adequate to effect, in an active gaseous body of equal bulk, and 36 times its weight, an entire change of properties. Should we assume in gaseous chemistry, 2 volumes of hydrogen, as the combining unit, or as representing an atom; then it should never unite in 3 volumes, or an atom and a half with another gas. Ammonia, however, is a compound of 3 volumes of hydrogen with 1 of azote; and if 2 volumes of hydrogen to 1 of oxygen be called an atom to an atom, surely 3 volumes of hydrogen to 1 of azote should be called an atom and a half to an atom. Yet the Daltonian Commentator, on the second occasion, counts one volume an atom of hydrogen, and on the first, two volumes an atom.

We would steer clear of all these gratuitous assumptions and contradictions, by making a single volume of hydrogen represent its atom, or prime equivalent. "There is an advantage," says Dr. Prout, "in considering the volume of hydrogen equal to the atom, as, in this case, the specific gravities of most, or perhaps all elementary substances, (hydrogen being one,) will either exactly coincide with, or be some multiple of the weights of their atoms; whereas, if we make the volume of oxygen unity, the weights of the atoms of most elementary substances, except oxygen, will be double that of their specific gravities, with respect to hydrogen. The assumption of the volume of hydrogen, being equal to the atom, will also enable us to find more readily, the specific gravities of bodies in their gaseous state, (either with respect to hydrogen, or atmospheric air,) by means of Dr. Wollaston's logometric scale.

"If the views we have ventured to advance be correct, we may almost consider the πρωτη ὑλη of the ancients to be realized in hydrogen; an opinion, by the by, not altogether new, If we actually consider this to be the case, and further consider the specific gravities of bodies, in their gaseous state, to represent the number of volumes condensed into one; or in other words, the number of the absolute weight of a single volume of the first matter (πρωτη ὑλη) which they contain, which is extremely probable; multiples in weight must always indicate multiples in volume, and *vice versa;* and the specific gravities or absolute weights of all bodies in a gaseous state, must be multiples of the specific gravity, or absolute weight of the first matter, (πρωτη ὑλη), because all bodies in a gaseous state, which unite with one another, unite with reference to their volume."

From these ingenious observations, we perceive the singular felicity of judgment, with which Sir H. Davy made choice of the single volume of hydrogen, for the unit of primary combination, in his elements of chemical philosophy.

Mr. Dalton's prelections on the atomic theory, and Dr. Thomson's commentary, had excited but a feeble sensation in the chemical world. That part of his system which treated on caloric, was blended with so much mere hypothesis, that chemists transferred a portion of the scepticism thus created, to his collation of primary and multiple combinations. It was Dr. Wollaston who first decided public opinion in favour of the doctrine of multiple proportions, by his elegant paper on super-acid, and sub-acid salts, inserted in the Philosophical Transactions for 1808. The object of the atomic theory has been no where so happily stated as by this philosopher, in the following sentence:

"But, since the publication of Mr. Dalton's theory of chemical combination, as explained and illustrated by Dr. Thomson, (System, 3d edit.), the inquiry which I had designed appears superfluous; as all the facts I had observed are but particular instances of the more general observation of Mr. Dalton, that in all cases the simple elements of bodies are disposed to unite atom to atom singly, or if either is in excess, it exceeds by a ratio to be expressed by some simple multiple of the number of its atoms."

It is evident from this passage, that the principle which presented itself to Mr. Dalton, on a review of the labours of *other* chemists, had really occurred to Dr. Wollaston from his *own*, and that he would unquestionably have been speedily led to its full developement. If Mr. Dalton had ever chanced to look into the neglected book of Higgins, there would have been little merit in his anticipation of what the advancement of analytical precision would infallibly have revealed in a very short period.

Dr. Wollaston, in the above decisive paper, demonstrates, that in the sub-carbonate and crystallized carbonate of potash, the relation of the carbonic acid to the base, in the first, is exactly one-half of what it is in the second. The same law is shown to hold with regard to the two carbonates of soda, and the two sulphates of potash; and being applied to his experiments on the compounds of potash and oxalic acid, leads him to conclude, that the neutral oxalate may be considered as consisting of 2 particles potash, with 1 acid; the binoxalate as 1 and 1, or 2 potash, with 2 acid; the quadroxalate as 1 and 2, or 2 potash, with 4 acid.

We cannot withhold from our readers the following masterly observations, which must make every one regret, that the first developement of the atomic theory had not fallen into such philosophical hands.

"But an explanation which admits a double share of potash in the neutral salts, (the oxalates), is not altogether satisfactory; and I am farther inclined to think, that when our views are sufficiently extended, to enable us to reason with precision concerning the proportions of elementary atoms, we shall find the arithmetical relation alone will not be sufficient to explain their mutual action, and that we shall be obliged to acquire a geometrical conception of their relative arrangement, in all the three dimensions of solid extension.

"For instance, suppose the limit to the approach of particles, to be the same in all directions, and hence their virtual extent to be spherical, (which is the most simple hypothesis); in this case, when different sorts combine singly, there is but one mode of union. If they unite in the proportion of two to one, the two particles will naturally arrange themselves at opposite poles of that to which they unite. If they be three, they might be arranged with regularity at the angles of an equilateral triangle, in a great circle surrounding the single spherule; but in this arrangement, for want of similar matter at the poles of this circle, the equilibrium would be unstable, and would be liable to be deranged by the slightest force of adjacent combinations; but, when the number of one set of particles exceeds in the proportion of 4 to 1, then, on the contrary, a stable equilibrium may again take place, if the four particles are situated at the angles of the four equilateral triangles composing a regular tetrahedron.

"But as this geometrical arrangement of the primary elements of matter is altogether conjectural, and must rely for its confirmation or rejection upon future inquiry, I am desirous that it should not be confounded with the results of the facts and observations related above, which are sufficiently distinct and satisfactory with respect to the existence of the law of simple multiples. It is perhaps too much to hope, that the geometrical arrangement of primary particles will ever be perfectly known; since, even admitting that a very small number of these atoms combining together, would have a tendency to arrange themselves in the manner I have imagined; yet until it is ascertained how small a proportion the primary particles themselves bear to the interval between them, it may be supposed that surrounding combinations, although themselves analogous, might disturb this arrangement; and in that case, the effect of such interference must also be taken into the account, before any theory of chemical combination can be rendered complete."

I am not aware, that any chemist has adduced experimental evidence, to prove that a "stable equilibrium may again take place, if the four particles are situated at the angles of the four equilateral triangles composing a regular tetrahedron." I have, therefore, much pleasure in referring to my researches on the constitution of liquid nitric acid, as unfolding a striking confirmation of Dr. Wollaston's true philosophy of atomical combination. When I wrote the following sentence, I had no recollection whatever of Dr. Wollaston's profound speculations on tetrahedral arrangement.—"We perceive, that the liquid acid of 1.420, composed of 4 primes of water + 1 of dry acid, possesses the greatest power of resisting the influence of temperature to change its state. It requires the *maximum* heat to boil it, when it distils unchanged; and the maximum cold to effect its congelation." See ACID (NITRIC,) in this Dictionary.

Here we have a fine example of the stability of equilibrium, introduced by the combination of four atoms with one. The discovery which I had also the good fortune to make with regard to the constitution of aqueous sulphuric acid, that the maximum condensation occurred, when one atom of the real acid was combined with three atoms of water, is equally consonant to Dr. Wollaston's views. "But in this arrangement," says Dr. Wollaston, "for want of similar matter at the poles of this circle, the equilibrium would be unstable, and would be liable to be deranged by the slightest force of adjacent combinations." Compare with this remark the following sentence from my paper on sulphuric acid, as published in the Journal of Science, October, 1817. "The terms of dilution are, like logarithms, a series of numbers in arithmetical progression, corresponding to another series, namely, the specific gravities, in geometrical progression. For a little distance on both sides of the point of greatest condensation, the series converges with accelerated velocity, whence the 10 or 12 terms on either hand, deviate a little from experiment." Page 126. Or in other words, a small addition of water or of acid to the above atomic group, produces a *great* change on the degree of condensation; which accords with the position "that the equilibrium would be liable to be deranged by the slightest force of adjacent combinations."

While considering this part of Dr. Wollaston's important paper, let me advert to the curious facts pointed out in the article NITRIC ACID, relative to the compound of one atom of dry acid and seven atoms water.—In my paper on the subject, published in the eighth number of the Journal of Science, I showed that this liquid combination was accompanied with the greatest condensation of volume, and the greatest disengagement of heat. In composing this Dictionary, I calculated, for the first time, the atomical constitution of the nitric acids employed by Mr. Cavendish, for congelation; and found with great satisfaction, that the same proportion which had exhibited, in my experiments, the most intense reciprocal action, as was indicated both by the aggregation of particles, and production of heat, was likewise that which most favoured solidification. Such acid congeals at — 2°; but when either stronger or weaker, it requires a much lower temperature for that effect.

3. The next capital discovery in multiple proportions, was made by M. Gay-Lussac, in 1808, and published by him in the second volume of the *Memoires d'Arcueil*. After detailing a series of fine experiments, he deduces the following important inferences;—"Thus it evidently appears, that all gases, in their mutual action, uniformly combine in the most simple proportions; and we have seen, in fact, in all the preceding examples, that the ratio of their union is that of 1 to 1, of 1 to 2; or of 1 to 3, by volume. It is important to observe, that when we consider the weights, there is no simple and definite relation between the elements of a first combination; it is only when there is a second between these same elements, that the new proportion of that body which has been added, is a multiple of the first. Gases, on the contrary, in such proportions as can com-

bine, give rise always to compounds, whose elements are, in volume, multiples the one of the other.

"Not only do the gases combine in very simple proportions, as we have just seen, but moreover, the apparent contraction of volume which they experience by combination, has likewise a simple relation with the volume of the gases, or rather with the volume of one of them."

By supposing the contraction of volume of the two gaseous constituents of water to be only equal to the whole volume of oxygen added, he found the ratio of the density of steam to be to that of air as 10 to 16; a computed result in exact correspondence with the experimental result lately obtained in an independent method, by the same excellent philosopher. "Ammoniacal gas is composed in volume," says he, "of 3 parts of hydrogen and 1 of azote, and its density, compared to that of air, is 0.596; but if we suppose the apparent contraction to be one-half of the total volume, we find 0.594 for its density. Thus it is demonstrated by this nearly perfect accordance, that the apparent contraction of its elements is precisely one-half of the total volume or rather double the volume of azote." M. Gay-Lussac subjoins to his beautiful memoir a table of gaseous combination, which, with some modifications derived from subsequent researches, will be inserted under the article Gas.

The same volume of the *Memoires* presents another important discovery of M. Gay-Lussac, on the subject of equivalent proportions. It is entitled, On the relation which exists between the oxidation of metals, and their capacity of saturation for the acids. He here proves, by a series of experiments, that the quantity of acid which the different metallic oxides require for saturation, is in the direct ratio of the quantity of oxygen, which they respectively contain. "I have arrived at this principle," says he, "not by the comparison of the known proportions of the metallic salts, which are in general too inexact to enable us to recognize this law, but by observing the mutual precipitation of the metals, from their solutions in acids."

When we precipitate a solution of acetate of lead, by a plate of zinc, there is formed a beautiful vegetation known under the name of the *tree of Saturn;* and which arises from the reduction of the lead by a galvanic process, as was first shewn by Silvester and Grotthus. We obtain at the same time a solution of acetate of zinc, equally neutral with that of the lead, and entirely exempt from this last metal. No hydrogen, or almost none, is disengaged during the precipitation; which proves, that the whole oxygen necessary to the zinc, for its becoming dissolved and saturating the acid, has been furnished to it by the lead.

If we put into a solution of sulphate of copper, slightly acidulous, bright iron turnings in excess, the copper is almost instantly precipitated; the temperature rises, and no gas is disengaged. The sulphate of iron which we obtain, is that in which the oxide is at a minimum, and its acidity is exactly the same as that of the sulphate of copper employed.

We obtain similar results, by decomposing the acetate of copper by lead, especially with the aid of heat. But since the zinc precipitates the lead from its acetic solution, we may conclude, that it would also precipitate copper, from its combination with the acetic acid. Experience is here in perfect accordance with theory.

We know with what facility copper precipitates silver, from its nitric solution. All the oxygen which it needs for its solution, is furnished to it by the oxide of silver; for no gas is disengaged, and the acidity is unchanged. The same thing happens with copper, in regard to nitrate of mercury and to cobalt, in regard to nitrate of silver. In these last examples, as in the preceding, the precipitating metal, finds in the oxide of the metal, which it precipitates, all the oxygen which is necessary to it for its oxidizement, and for neutralizing to the same degree the acid of the solution.

These incontestable facts naturally conduct to the principle announced above, that the acid in the metallic salts, is directly proportional to the oxygen in their oxides. In the precipitation of one metal by another, the quantity of oxygen in each oxide remains the same, and consequently the larger dose of oxygen the precipitating metal takes, the less metal will it precipitate.

M. Gay-Lussac next proceeds to show, with regard to the same metals at their different stages of oxidizement, that they require of acid, a quantity precisely proportional to the quantity of oxygen they may contain; or that the acid in the salts, is exactly proportional to the oxygen of the oxides. A very important result of this law, is the ready means it affords of determining the proportions of all the metallic salts. The proportions of one metallic salt, and the oxidation of the metals, being given, we may determine those of all the salts of the same genus; or the proportions of acid, and of oxide, of all the metallic salts; and the oxidation of a single metal being given, we can calculate the oxidation of all the rest. Since the peroxides require most acid, we can easily understand how the salts containing them, should be in general more soluble than those with the protoxide.

M. Gay-Lussac concludes his memoir with this observation. When we precipitate a metallic solution, by sulphuretted hydrogen, either alone or combined with an alkaline base, we obtain a sulphuret or a metallic hydrosulphuret. In the first case, the hydrogen of the sulphuretted hydrogen combines with all the oxygen of the oxide, and the sulphur forms a sulphuret with the metal; in the second case, the sulphuretted hydrogen combines directly with the oxide, without being decomposed, and its proportion is such, that there is sufficient hydrogen to saturate all the oxygen of the oxide. The quantity of hydrogen neutralized, or capable of being so, depends therefore on the oxidation of the metal, as well as the quantity of the sulphur, which can combine with it. Of consequence, the same metal forms as many distinct sulphurets, as it is susceptible of distinct stages of oxidation in its acid solutions. And as these degrees of oxidation are fixed, we may also obtain sulphurets, of definite proportions, which we can easily determine, according to the quantity of oxygen to each metal, and the proportions of sulphuretted hydrogen.

The next chemist who contributed essentially to the improvement of the equivalent ratios of chemical bodies, was Berzelius. By an astonishing number of analyses, executed for the most part with remarkable precision, he enabled chemical philosophers to fix with corresponding accuracy, the equivalent ratios reduced to their lowest terms. He himself took oxygen as the unit of proportion.

The results of all this emulous cultivation, were combined and illustrated with original researches, by Sir H. Davy, in his Elements of Chemical Philosophy published in 1812. In this system of truths, which will never become obsolete, we find the claims of Mr. Higgins to the discovery of the atomic theory justly advocated.

But what peculiarly characterizes this chemical work, is the sound antihypothetical doctrines which it inculcates on chemical combination. "Mr. Higgins," says Sir H. "has supposed that water is composed of one particle of oxygen and one of hydrogen, and Mr. Dalton of an atom each; but in the doctrine of proportions derived from facts, it is not necessary to consider the combining bodies, either as composed of indivisible particles, or even as always united, one and one, or one and two, or one and three proportions. Cases will be hereafter pointed out, in which the ratios are very different; and at present, as we have no means whatever of judging either of the relative numbers, figures, or weights, of those particles of bodies which are not in contact, our numerical expressions ought to relate only to the results of experiments."

He conceives that the calculations will be much expedited, and the formulæ rendered more simple, by considering the smallest proportion of any combining body, namely, that of hydrogen, as the integer. This radical proportion of hydrogen, is the *πρωτη ὕλη* of the ancient philosophers.

It has been objected by some, to our assuming hydrogen as the unit, that the numbers representing the metals, would become inconveniently large. But this could never be urged by any person acquainted with the theory of numbers. For in what respect is it more convenient to reckon barium 8.75 on the atomic scale, or 8.75 × 16 = 140 on Sir H. Davy's scale of experiment? or is it any advantage to name, with Dr. Thomson, tin = 7.375, or to call it 118, on the plan of the English philosopher? If the combining ratios of all bodies be multiples of hydrogen, as is probable, why not take hydrogen as the unit? I think this question will not be answered in the negative, by those who practise the reduction of chemical proportions. The defenders of the Daltonian hypothesis, that water consists of one atom oxygen to one atom hydrogen, may refer to Dr. Wollaston's scale, as authority for taking oxygen as the unit. But that admirable instrument, which has at once subjected thousands of chemical combinations to all the despatch and precision of logometric calculation, is actually better adapted to the hydrogen unit, than to the oxygen. For if we slide down the middle rule, till 10 on *it* stand opposite to 10 hydrogen on the left side, every thing on the scale is given in accordance with Sir H. Davy's system of primary proportions, and M. Gay-Lussac's theory of gaseous combination. This valuable concurrence, as is well pointed out by Dr. Prout, we lose, by adopting the volume of oxygen as *radix*.

In the first part of the Phil. Trans. for 1814, appeared Dr. Wollaston's description of his scale of chemical equivalents, an instrument which has contributed more to facilitate the general study and practice of chemistry than any other invention of man. His paper is further valuable, in presenting a series of numbers denoting the relative primary proportions, or weights of the atoms of the principal chemical bodies, both simple and compound, determined with singular sagacity, from a general review of the most exact analyses of other chemists, as well as his own.

The list of substances which he has estimated, is arranged on one or other side of a scale of numbers, in the order of their relative weights, and at such distances from each other, according to their weights, that the series of numbers placed on a sliding scale can at pleasure be moved, so that any number expressing the weight of a compound, may be brought to correspond with the place of that compound, in the adjacent column. The arrangement is then such, that the weight of any ingredient in its composition, of any reagent to be employed, or precipitate that might be obtained in its analysis, will be found opposite the point, at which its respective name is placed.

If the slider be drawn upwards, till 100 corresponds to muriate of soda, the scale will then show how much of each substance contained in the table, is equivalent to 100 of common salt. It shows, with regard to the different views of this salt, that it contains 46.6 dry muriatic acid, and 53.4 of soda, or 39.8 sodium, and 13.6 oxygen; or if viewed as chloride of sodium, that it contains 60.2 chlorine and 39.8 sodium. With respect to reagents, it may be seen, that 283 nitrate of lead, containing 191 of litharge, employed to separate the muriatic acid, would yield a precipitate of 237 muriate of lead, and that there would then remain in solution, nearly 146 nitrate of soda. It may at the same time be seen; that the acid in this quantity of salt, would serve to make 232 corrosive sublimate, containing 185.5 red oxide of mercury; or make 91.5 muriate of ammonia, composed of 62 muriatic gas (or hydromuriatic acid), and 29.5 ammonia. The scale shows also, that for the purpose of obtaining the whole of the acid in distillation, the quantity of oil of vitriol required is nearly 84, and that the residuum of this distillation would be 122 dry sulphate of soda, from which might be obtained, by crystallization, 277 of glauber salt, containing 155 water of crystallization. These, and many more such answers, appear at once, by bare inspection, as soon as the weight of any substance intended for examination is made, by motion of the slider, correctly to correspond with its place in the adjacent column. Now surely the accurate and immediate solution of so many important practical problems, is an incalculable benefit conferred on the chemist.

With regard to the method of laying down the divisions of this scale, those who are accustomed to the use of other sliding rules, and are practically acquainted with their properties, will recognize upon the slider itself, the common Gunter's line of numbers, (as it is called), and will be satisfied, that the results which it gives are the same that would be obtained by arithmetical computation.

Those who are acquainted with the doctrine of ratios, and with the use of logarithms as measures of ratios, will understand the principle on which this scale is founded, and will not need to be told, that all the divisions are logometric; consequently, that the mechanical addition and subtraction of ratios here performed by juxtaposition, corresponds in effect to the multiplication and division of the numbers, by which those ratios are expressed in common arithmetical notation.

In his Essay on the cause of Chemical Proportions, Berzelius proposed a system of signs, to denote atomical combinations, which it may be proper briefly to explain. This sign is the initial letter, and by itself always expresses one atom, volume, or prime of the substance. When it is necessary to indicate several volumes or primes, it is done by prefixing the number; for example, the cuprous oxide, or protoxide of copper, is composed of a prime of oxygen and a prime of metal; its sign is therefore $Cu + O$. The cupric oxide, or deutoxide of copper, is composed of 1 prime metal, and 2 primes oxygen; therefore its sign is $Cu + 2O$. In like manner the sign for sulphuric acid is $S + 3O$; for carbonic acid, $C + 2O$; for water, $2H + O$, &c.

When we express a compound prime of the first order, or binary, we throw away the +, and place the number of primes above the letter, as the index or exponent is placed in arithmetic. For example, $CuO + SO^3$ = sulphate of copper; $CuO^2 + 2SO^3$ = bi-deutosulphate of copper, or persulphate. These formulæ have this advantage, that if we take away the oxygen, we see at once the ratio between the radicals. As to the primes of the second order, or ternary compounds, it is but rarely of any advantage to express them by formulæ, as one prime; but if we wish to express them in that way, we may do it by using the parenthesis, as is done in algebraic formulæ; for example, according to Berzelius, alum is composed of 3 primes of sulphate of alumina, and 1 of sulphate of potash. Its symbol is $3(AlO+SO^3) + (PoO+SO^3)$. The prime of ammonia is $3\,HN$; viz. 3 primes hydrogen + 1 nitrogen. We shall use these abbreviations in our table of equivalent primes, at the end of the volume.

To reduce analytical results, as usually given for 100 parts, to the equivalent prime ratios, or, in hypothetical language, to the atomic proportions, is now a problem of perpetual recurrence, with which students are perplexed, as no rule has been given for its ready solution. Though numerous examples of its solution occur in this Dictionary, we shall here explain it in detail.

As in all reasoning we must proceed from what is known or determinate, to what is unknown or indeterminate, so in every analysis, there must be one ingredient whose prime equivalent is well ascertained. This is employed as the common measure, and the proportions of the rest are compared to it. Let us take, for instance, Sir H. Davy's analysis of fluate of lime, to determine the unknown number, that should denote the prime of fluoric acid. We know, first of all, that 2 primes of oxygen = 2, combine with 1 of carbon = 0.75, to form the compound prime 2.75 of carbonic acid. We likewise know that carbonate of lime consists of 43.6 carbonic acid + 54.4 lime. We therefore make this proportion, to determine the prime equivalent of lime.

1. 43.6 : 54.4 :: 2.75 : 3.56 = prime of lime.

2. We know that 100 parts of dry sulphate of lime, consist of 41.6 lime and 58.4 acid. Hence, to find the prime of sulphuric acid, we make this proportion:

41.6 : 58.4 :: 3.56 : 5 = prime of sulphuric acid.

3. Sir H. Davy obtained from 100 grains of fluor spar in powder, acted on with repeated quantities of sulphuric acid, and ignited, 175.2 grains of sulphate of lime. Now, since 100 grains of sulphate of lime contain, as above, 41.6 of lime, we have this proportion:

100 : 41.6 :: 175.2 : 72.88 = lime, corresponding to 175.2 grains of sulphate, and which previously existed in the 100 gr. of fluor spar. If from 100 we subtract 72.88, the difference 27.12 is the fluoric acid, or the other ingredient of the fluor, which saturated the lime. Now to find its prime equivalent, we say,

72.88 : 3.56 :: 27.12 : 1.325 = the prime or atom of fluoric acid from Sir H. Davy's experiment. Had we taken Dr. Thomson's number 3.625, as representing the atom of lime, the atom of fluoric acid would come out 1.3015. As the Doctor had a particular hypothesis to support, which required the weight of the acid atom to be a great deal less, he deduces it, from the same *data*, to be only 1.0095. By what new process of arithmetic he brought out this number, it is impossible to conjecture. But no doubt he devoted some pains to the computation, since he rears on that unsubstantial basis, a long fabric of atomic induction.

We shall give another example, derived from a more complex subject.

M. Vauquelin found, that 33 parts of lime, saturated with sorbic acid, and carefully dried, weighed 100 grains. Hence the difference, 67 grains, was acid. To find its equivalent prime, we say,

As 33 : 67 :: 3.56 = the prime of lime : 7.23 = the prime of the acid. But as he brought it to absolute neutrality by a small portion of potash, we may take 7.5 for the prime.

M. Vauquelin subjected the acid, as it exists in the dry sorbates of lead and copper, to igneous analysis; and obtained the following results:

Hydrogen,	16.8
Carbon,	28.3
Oxygen,	54.9
	100.0

Now we must find such an assemblage of the primes or atoms of these elements, as will form a sum-total of 7.5; and at the same time be to each other, in the above proportions. The following very simple rule will give a ready approximation; and by a common sliding scale, it may be worked by inspection.

Multiply each proportion per cent, by the compound prime, and compare the products with the multiples of the constituent primes. You can then estimate the number of each prime requisite to compose the whole. Thus,

			Theory.	*Experiment.*
0.168 × 7.5 = 1.2600	or 10 hydrogen	= 1.25	16.7	16.8
0.283 × 7.5 = 2.1225	3 carbon	= 2.25	30.0	28.3
0.549 × 7.5 = 4.1175	4 oxygen	= 4.00	53.3	54.9
		7.50	100.0	100.0

The differences between these theoretical and experimental proportions, are probably within the limits of the errors of the latter in the present state of analysis.

If on Dr. Wollaston's scale we mark with a type or a pen, 2h, 3h, &c. up to 10h; 2c, 3c, 4c, 5c; and 2n, 3n, 4n; respectively opposite to twice, thrice, &c. the atoms of hydrogen, carbon, and nitrogen, as is already done for oxygen, (with the exception of the fourth, where copper stands), we shall then have ready approximations to the prime components, by inspection of the scale. Move the sliding part, so that one of the quantities per cent, may stand opposite the nearest estimate of a multiple prime of that constituent. Thus we know that hydrogen, carbon, and oxygen, bear the relation to each other of 1, 6, 8; and, of course, the latter two, that of 3 to 4. But 54.9 oxygen, being more than one half of 100, the weight of oxygen in the compound prime is more than the half of 7.5, and therefore points to 4. Place 54.9 opposite 4 oxygen, (where copper stands), we shall find 18 opposite 10 hydrogen, and 30.7 opposite 3 carbon. Here we see the proportions of carbon and hydrogen, are both greater than by Vauquelin's analysis. Try 51 opposite 4 oxygen, then opposite 3 carbon we have, 28.7, and opposite 10 hydrogen 16.9. The proportions I have calculated arithmetically above, seem somewhat better approximations; they were deduced from hydrogen 0.125, and carbon 0.75, instead of 0.132 and 0.754, as on the scale.

If the weight of the compound prime is not given, then we must proceed to estimate the nearest prime proportions, after inspection of those per cent. The scale may be used with advantage, as just now explained.

The following case has been reckoned difficult of solution, and has been even involved in an algebraic formula. Let us suppose a vegetable acid, containing combined water, whose prime equivalent is to be determined by experiment. A crystallized salt is made with *it*, for example, and a determinate quantity of soda. Suppose the alkali to form 26 per cent of the salt. The rest is water and acid. Dissolve 100 grains, and add them to an indefinite quantity of the solution of any salt, with whose base the vegetable acid forms an insoluble compound. Dry and weigh this precipitate. Without decomposing the latter, we have sufficient data for determining the prime equivalent of the real acid. We make this proportion: As the weight of soda is to *its* prime equivalent, so is the weight of the precipitate, to the prime of the compound. Suppose 148 grains of an insoluble salt of lead to have been obtained; then $26 : 3.95 :: 148 : 22.1 =$ the prime of the salt of lead. From this, if we deduct the weight of the prime equivalent of oxide of lead, $= 14$, we have 8.1 for the prime equivalent of the acid. And the crystallized salt must have consisted of,

Dry acid,	53.3
Soda,	26.0
Water,	20.7
	100.0

As the above numbers were assumed merely for arithmetical illustration, the water is not atomically expressed. Indeed the problem of finding the acid prime, does not require the salt to be either dried or weighed. A solution would suffice. Saturate a known weight of alkali, with an unknown quantity of the crystallized acid. Add this neutral solution, to a redundant quantity of solution of nitrate of lead. Wash, dry, and weigh the insoluble precipitate, and apply the above rule.

There are three systems of equivalent numbers at present employed: 1st, That having oxygen as the radix; 2d, That having one volume of hydrogen, as the radix; 3d, That having two volumes of hydrogen as the radix, on the Daltonian supposition, that two volumes of hydrogen contain the same number of atoms, as one volume of oxygen. As this hypothesis is destitute of proof, it evidently should be discarded from physical science. Since the volume of hydrogen is equal in weight to 1-16th the weight of the volume of oxygen, the former two systems are mutually convertible, by multiplying the number oxygen, in the oxygen ratio, by 16, or 4×4, to obtain the number in the hydrogen scale; and this is re-converted by the inverse operation, namely, dividing by 16, or by 4×4.

Dr. Wollaston's scale, and Sir H. Davy's proportional numbers, are adapted to the idea that water is a compound of 1 hydrogen + 7.5 oxygen by weight, or 15 + 1 by volume. Their mutual conversion is therefore very easy, for if we add to Dr. Wollaston's number, its half, the sum is Sir H. Davy's; and of course, if we subtract from the number of the latter, its third, the remainder is Dr. Wollaston's number. There is one very frequent variation in the weights of the primes among the best writers, namely, doubling or halving the number. This difference is occasioned generally by an uncertainty about the first term or proportion in which the body combines with oxygen; some chemists reckoning that a protoxide which others consider a deutoxide. Thus Sir H. Davy gives 103 as the number representing iron; from which, if we deduct $\frac{103}{3} = 34.3$, the remainder 68.7 is nearly double of 34.5, the number of Dr. Wollaston. But Mr. Porrett has very ingeniously shown that perhaps $\frac{35}{2} = 17.5$, is to be preferred.*

Essences. Several of the volatile or essential oils are called essences by the perfumers.

Ether. A very volatile fluid, produced by the distillation of alcohol with an acid.

When strong sulphuric acid is poured upon an equal weight of alcohol, the fluids unite with a hissing noise and the production of heat, at the same time that a fragrant vegetable smell is perceived, resembling that of apples. It is much better and safer, however, to add the acid by small portions at a time, at such intervals as that no perceptible heat may be produced. The mixture may be made in a glass retort, and the distillation performed by regulated heat on a sand-bath, a large tubulated receiver being previously well adapted, and kept cool by immersion in water, or the frequent application of wet cloths. A bent glass tube luted to the tubulure of the receiver, and having its extremity immersed in a little water or mercury, will allow the gases to escape, and confine the condensible vapour. The first product is a fragrant spirit of wine, which is followed by the ether, as soon as the fluid in the retort begins to boil. At this period, the upper part of the receiver is covered with large distinct streams of the fluid which run down its sides. After the ether has passed over, sulphurous acid arises, which is known by its white fume and peculiar smell. At this period the receiver must be unluted and removed, care being taken to avoid breathing the penetrating fumes of the acid; and the fire must at the same time be moderated, because the residue in the retort is disposed to swell. A light yellow oil, called sweet oil of wine, comes over after the ether, and is succeeded by black and foul sulphuric acid. The residue varies in its properties according to the management of the heat. If the fire be much increased toward the end of the process, the sulphurous acid that comes over, will be mixed with vinegar.

The ether comes over mixed with alcohol and some sulphurous acid. It was usual to add some distilled water to this product, which occasioned the ether to rise to the top. Rectification is absolutely necessary, if the ether have a sulphurous smell; and this is indeed the better method in all cases, because the water added in the old method always absorbs about one-tenth part of its weight of ether, which cannot be recovered without having recourse to distillation; and also because the ether is found to absorb a quantity of the water. Previous to the rectification, a small quantity of black oxide of manganese should be added, shaking the mixture occasionally during 24 hours. Proust prefers clean slaked lime, as recommended by Woulfe; observing that the bottle must not be above three parts filled, and that it must be moved about in cold water for some minutes before the cork is taken out.

The inexperienced chemist must be reminded, that the extreme inflammability of alcohol, and still more of ether; the danger of explosion which attends the sudden mixture and agitation of concentrated acids and alcohol; and the suffocating effect of the elastic fluids, which might fill the apartment if inadvertently disengaged; are all circumstances which require cautious management.

Sulphuric ether is a very fragrant, light, and volatile fluid. Its evaporation produces extreme cold. It is highly inflammable, burns with a more luminous flame than alcohol, which is of a deep blue, and emits more smoke. At 46° below 0 of Fahr. it becomes solid. It dissolves essential oils and resins, and camphor very plentifully. By long digestion it dissolves 1-13th of sulphur in the light, and 1-17th in the dark. This preparation Mr. Favre recommends as an excellent test of lead in wine, which it throws down in a black precipitate. Mixed with the muriatic solution of gold, it retains a portion of the metal in solution for some time.

* To give ether its utmost purity, we must add to the common purified ether, dry subcarbonate of potash in powder, till the last portions are not wetted, and draw off the ether by distillation. Its sp. gr. will fall from 0.775 to 0.746. Being thus deprived of its water, it must next be freed from alcohol, by digesting it on dry muriate of lime, and decanting the supernatant liquid, which is ether of sp. gr. 0.632 at 60°, according to Lowitz. Distillation increases its density to 0.7155 at 68°, according to M. T. de Saussure.

Ether boils in the atmosphere at 98° F. and in vacuo at — 20°. The density of its vapour as determined by M. Gay-Lussac, is 2.586, that of air being 1. Ether admitted to any gas standing over mercury, doubles its bulk at atmospheric temperatures. If oxygen be thus expanded with ether, and then mixed with three times its bulk of pure oxygen, on being kindled it explodes, forming carbonic acid and water. By detonating such a mixture M. de Saussure has lately inferred ether to consist of

Hydrogen,	14.40
Carbon,	67.98
Oxygen,	17.62
	100.00

These proportions per cent, correspond to

Olefiant gas,	80.05
Water,	19.95
	100.00

Or very nearly 5 primes olefiant gas, consisting of 5 carbon + 5 hydrogen;

$$(0.750+0.125) \times 5 = 4.375$$

1 prime water, or 1 hydrogen + 1 oxygen, } = 1.125

5.500

Or 6 hydrogen + 5 carbon + 1 oxygen.

By passing ether through a red-hot porcelain tube, it is resolved into heavy inflammable air, a viscid volatile oil, a little concrete oil, and charcoal and water.

Ten parts of water combine with one of ether. Sulphuric acid converts ether into sweet oil of wine. If a very little ether be thrown into a large bottle filled with chlorine, a white vapour soon rises, followed by explosion and flame. Charcoal is deposited, and carbonic acid gas formed.

If we apply to ether that principle of research invented by M. Gay-Lussac, and so successfully applied by him to iodine and prussic acid, we shall find that,

2 volumes of olefiant gas,	= 0.9722 × 2 =	1.9444
1 do. vapour of water,	=	0.6249
Condensed into one volume of vapour of ether	=	2.5693
Which is very nearly the experimental sp. gr.	=	2.5860

On this view, the vapour of ether contains one-half of the combined water, that the vapour of alcohol does.

But two volumes of olefiant gas consist of four volumes of hydrogen, and four of carbon, in a condensed state; and one volume of aqueous vapour consists of one volume of hydrogen, and half a volume of oxygen. Hence the ratio of the weights of the constituents will become, on the hypothetical oxygen scale, in which half a volume of oxygen represents one atom,

5 atoms	hydrogen,	= 0.125 × 5 =	0.625 ...	13.513
4	carbon,	= 0.750 × 4 =	3.000 ...	21.622
1	oxygen,	= 1.000 × 1 =	1.000 ...	64.865
			4.625	100.000

These proportions differ from those of M. de Saussure, in making the carbon a little more, and the oxygen a little less, than he found.

Ethers, exactly the same with the sulphuric, may be obtained by passing alcohol through phosphoric and arsenic acids concentrated and heated.

Another kind of ethers are those which result from the combination of the alcohol with the acid employed to make them. Nine such ethers are known. Muriatic ether, nitric ether, hydriodic ether, acetic ether, benzoic ether, oxalic ether, citric ether, tartaric ether, gallic ether; the first four are more volatile than alcohol; the rest are much less so, for they boil with more difficulty than water.

Muriatic ether. It is formed by saturating alcohol with muriatic acid gas; or still better by mixing together equal bulks of alcohol and concentrated liquid muriatic acid, and heating the mixture in a glass retort connected with a Woulfe's apparatus. The first bottle should contain a quantity of water, at about 80° F.; the second should be surrounded with ice. From 10 ounces of acid, and an equal bulk of alcohol, 1.2 ounces of ether may be obtained.

Under the barometric pressure of 30 inches, this ether is always gaseous at 51°, and all higher temperatures. In the state of gas it is colourless, and without action on litmus, or violets. Its odour is very strong and analogous to that of sulphuric ether; its taste is perceptibly saccharine; and its sp. gr. compared to that of air is 2.219.

In the liquid state at 40° F., its sp. gr. is 0.874. Poured on the palm of the hand, it immediately boils, and produces much cold. At a dull red heat, muriatic ether is converted into muriatic acid gas, and olefiant gas, with, most probably, water; for M. Thenard gave for its composition, from the mean of many eudiometric, and other experiments, acid 29.48 + carbon 36.6 + oxygen 23.28 + hydrogen 10.64 = 100.—*Mem. d'Arcueil*, i. 343. Eight years thereafter, he modified these results into 46.5 acid + 53.5 alcohol, (32.6 olef. gas + 20.9 water).—*Traité*, iii. 977.

According to MM. Colin and Robiquet, (*Annales de Chimie et de Physique*, i. p. 348.) one volume of muriatic ether, passed through a porcelain tube at a dull red heat, is resolved into a mixture of one volume olefiant gas, and one volume muriatic gas. By adding the density of

olefiant gas = 0.9722 to that of
muriatic acid gas = 1.2840

We have the sum = 2.2562, which is nearly the sp. gr. of the vapour by experiment = 2.2190.

When a lighted taper is brought near the surface of this ether, it immediately takes fire, and burns with a greenish flame. Muriatic gas, carbonic acid, and water result. Similar products are obtained by firing a mixture of its vapour with oxygen, either by the taper or electric spark. If the oxygen be to the vapour in the ratio of 3 to 1, a violent detonation takes place, which breaks common eudiometers.

Water dissolves of muriatic ether a volume equal to its own, at mean pressure and temperature. The solution has a sweet and cooling taste, analogous to that of peppermint. Although it be very soluble in alcohol, water separates the whole of it. Chlorine instantly decomposes muriatic ether. Nitrate of silver and protonitrate of mercury, two salts, which suddenly occasion precipitates in waters containing muriatic acid, either free or combined with a salifiable base, produce no immediate cloud with this ether. It is only after some hours contact that we begin to perceive an action; and even after three months, the muriatic acid is not completely thrown down. These experiments must be made in phials closed with well ground stoppers.

The ether produced by treating certain muriates, especially the fuming muriate, or chloride of tin, with alcohol, is muriatic ether. The only difference which exists between the former and this kind, is that the ether formed with the acid, is a little more volatile than the ether made with the chlorides.

Nitric ether. This ether is prepared by distilling equal parts by weight of alcohol, and the aquafortis of commerce. After having introduced them into a retort capable of holding double the bulk, it must be put in connexion with a Woulfe's apparatus, of which the first bottle is empty, and the other four half filled with saturated brine. The whole bottles must be put into an oblong box, and surrounded with a mixture of snow and salt. We then apply a gentle heat from a charcoal chauffer. As soon as the liquor begins to boil, we must instantly withdraw the heat, and, if necessary, check the violence of the ebullition by the application of a moist sponge, or rag, to the retort. The operation is finished, when it spontaneously ceases to boil. By this time the product forms a little more than one-third of the alcohol and acid employed.*

† *A new process for Nitrous Ether, by Professor* R. Hare, M. D.

The making of nitrous ether is a critical process. The action of the materials will often spontaneously increase so as to produce explosion. It may be conducted with ease and safety by means of a three necked bottle represented by fig. 7. (See plate, at the end of the work, which exhibits the eudiometers.) The two outermost necks are furnished with funnels, and the central one with a tube bent a little more than at right angles, and passing through ice to the bottom of a bottle surrounded by the same. The acid and alcohol ought to be very strong. Let a gill of the latter be poured into the bottle, and then add as much acid as will make it boil briskly. When the effervescence relaxes, add more acid until the addition of this produces no great effect. Then add more alcohol, and again more acid, till the bottle becomes one third full. The ether will be rapidly formed and collected in the bottle into which the recurved tube leads. This tube is represented in the plate of about one third of the proper length. There should be a triangular wooden trough adapted to it for holding ice or snow.

It might be an improvement if another neck were added, through which the residual liquor might be drawn out. With this addition, the distillation of ether might be conducted in a way analogous to that of the distillation of whiskey by the celebrated Scotch still.†

* But ether is not the sole product of the operation. We obtain also much protoxide of azote and water, a little azote, deutoxide of azote, carbonic acid gas, nitrous acid gas, acetic acid, and a substance easily carbonized. We are thus led to suppose that a portion of the alcohol is completely decomposed by the nitric acid, that it yields almost all its hydrogen to the oxygen of this acid, and that hence result all the products, besides the ether, whilst the alcohol and the nitrous acid unite to constitute the ether properly so called. The whole ether comes over as well as the azote, protoxide of azote, deutoxide of azote, and carbonic acid. As to the water, nitrous and acetic acids, they are disengaged only in part, as well as a portion of the alcohol and nitric acid which escape their reciprocal action. In fact, the easily charred matter remains in the retort along with a little acetic acid, about 78 parts of nitric acid, 60 of alcohol, and 284 of water, supposing that we had operated upon 500 parts of alcohol, and as much dilute nitric acid.

It is because there is formed so great a quantity of gas, that the salt water and refrigeration are required. Without these precautions, the greater part of the ether would be carried off into the atmosphere; and even with them, some is always lost.

On unluting the apparatus, there is found in the first bottle a large quantity of yellowish liquid, formed of much weak alcohol, of ether, with nitrous, nitric, and acetic acids. In the second, we find on the surface of the salt water, a pretty thick stratum of ether contaminated with a little acid and alcohol. In the third, a thinner layer of the same, and so on.

These layers are to be separated from the water by a long-necked funnel, mixed with the liquid of the first bottle, and redistilled from a retort by a gentle heat, into a receiver surrounded with ice. The first product is an ether, which may be entirely deprived of acid, by being placed in contact with cold quicklime in a phial, and decanted off it, in about half an hour. From a mixture of about 500 parts of alcohol, and as much acid, about 100 parts of excellent ether may be procured.

Nitric ether in its ordinary state is a liquid of a yellowish-white colour. It has an odour analogous to that of the preceding ethers, but much stronger, so that its inhalation into the nostrils produces a species of giddiness. It does not redden litmus. Its taste is acrid and burning. Its sp. gr. is greater than that of alcohol, and less than that of water. It boils at 70° F. or at that temperature sustains a column equal to 30 inches of mercury. Poured into the hand, it immediately boils, and creates considerable cold. It is sufficient to grasp in our hands a phial containing it, to see bubbles immediately escape. It takes fire very readily, and burns quite away, with a white flame.

When agitated with 25 or 30 times its weight of water, it is divided into three portions. One, the smallest, is dissolved; another is converted into vapour; and a third is decomposed. The solution becomes suddenly acid; it assumes a strong smell of apples; and, if after saturating with potash the acid which it contains, it be subjected to distillation, we withdraw the alcohol, and obtain a residue formed of nitrate of potash. We see here that there is a separation, of one part of the two bodies, which constitute the ether. Left to itself in a well stopped bottle, the ether suffers a spontaneous change, for it becomes perceptibly acid. By distillation, acid is instantly developed, which shows that heat favours its decomposition. If instead of exposing the nitric ether to a distilling heat, we make it traverse an ignited tube, it is completely decomposed. 41.5 parts of ether thus decomposed, yielded 5.63 water, containing a little prussic acid; 0.40 of ammonia; 0.80 oil; 0.30 of charcoal; 0.75 carbonic acid; 29.9 of gases, formed of deutoxide of azote, azote, subcarburetted hydrogen, and oxide of carbon. The loss amounted to 3.72.

It is very slowly decomposed by potash. When combined with nitrous acid gas or acetic acid, so intimate a union is effected, that in making the compound pass through the most concentrated alkalis, only a small portion of its acid is separated. According to M. Thenard, from whose excellent memoir in the first volume of the *Memoires d'Arcueil* the above interesting facts are taken, nitric ether is composed in the hundred parts of

Carbon	28.65	or 4 primes	3.0
Azote	14.49	1	1.75
Hydrogen	8.54	7	0.875
Oxygen	48.52	5	5.000
			10.625

Perhaps with a little management we might coax these refractory atoms into a better correspondence with M. Thenard's results; but in such freaks of fancy, it is foolish to indulge. This distinguished chemist indeed admitted, that the analysis is imperfect; and promised to repeat it in another and better way by explosion with oxygen, of which gas, nitric ether, from its great volatility, quintuples the volume, at ordinary temperatures.

Hydriodic ether. M. Gay-Lussac, to whom the formation of this ether is due, obtained it by mixing together equal bulks of alcohol and a coloured hydriodic acid, sp. gr. 1.700, distilling the mixture by the heat of a water bath, and diluting with water the product which gradually collects in the receiver. The ether precipitates in the form of small globules, which have at first a milky aspect, but which by their union form a transparent liquid. It is purified by repeated washings with water.

This ether does not redden litmus; its smell is strong, and analogous to that of the rest. Its sp. gr. is 1.9206 at 72° F. It assumes in the course of a few days a rose colour, which becomes no deeper by time, and which mercury and potash instantly remove, by seizing the iodine, which occasions it.

Hydriodic ether boils at 156° F. At ordinary temperatures, it does not kindle by the approach of a lighted taper to its surface, but only exhales purple vapours, when poured drop by drop on burning coals. Potassium keeps in it, without alteration. Potash does not instantaneously change it. The same may be said of nitric and sulphurous acids, as well as chlorine. By passing it through an incandescent tube, it is converted into a carburetted inflammable gas; into dark brown hydriodic acid; into charcoal; and *flocculi*, whose odour is ethereous, and which M. Gay-Lussac considers as a sort of ether, formed of hydriodic acid, and of a vegetable product different from alcohol. These flakes melt in boiling water, and assume on cooling the transparency and colour of wax. They are much less volatile than hydriodic ether, and evolve much more iodine when projected on glowing coals.

Ethers from vegetable acids. Almost all the vegetable acids dissolve in alcohol, and separate from it again by distillation, without any peculiar product being formed, however frequently we act upon the same quantity of acid and alcohol. Such is the case at least with the tartaric, citric, malic, benzoic, oxalic, and gallic acids. But this cannot be said of the acetic. The action of this acid on alcohol is such, that by means of repeated distillations, the two bodies disappear, and form a true ether; whence it has been inferred by M. Thenard, that this fluid is probably the only one of the vegetable acids at present known, which can exhibit by itself the phenomena of etherization. But if instead of putting the vegetable acids alone in contact with alcohol, we add to the mixture one of the concentrated mineral acids, we can then produce with several of them compounds analogous to the preceding ethers. The mineral acid probably acts here by condensing the alcohol, and elevating the temperature, to such a degree as to determine the requisite chemical reaction.

Acetic ether was discovered by Scheele, but first accurately examined by M. Thenard.

Take 100 parts of rectified alcohol, 63 parts of concentrated acetic acid, 17 parts of sulphuric acid of commerce. After having mixed the whole, introduce them into a tubulated glass retort, connected with a large globular receiver surrounded with cold water. On applying heat, the liquid enters into ebullition; and when 123 parts of ether have passed over, the process may be stopped. To render it perfectly pure, we have only to place it, for half an hour, in contact with 10 or 12 parts of the caustic potash of the apothecary, in a corked phial, and to agitate from time to time. Two strata will form; the undermost thin, composed of potash and acetate of potash dissolved in water; the uppermost much more considerable, consisting of pure ether, which may be separated by a long-necked funnel. The sulphuric acid does not enter at all into the composition of this ether. It merely favours the reaction of the alcohol and acetic acid. This mode is much better than the old one, of distilling many times over, the same mixture of acetic acid and alcohol. Or we may obtain an excellent acetic ether, very economically, by taking 3 parts of acetate of potash, 3 of concentrated alcohol, and 2 of oil of vitriol; introducing the mixture into a tubulated retort, and distilling to perfect dryness; then mixing the product with the fifth part of its weight of oil of vitriol, and, by a careful distillation, drawing off as much ether as there was alcohol employed.

Acetic ether is a colourless liquid, having an agreeable odour of sulphuric ether and acetic acid. It does not redden litmus paper, or tincture of turnsole. Its taste is peculiar. Its sp. gr. is 0.866, at 44.5° F.

Under the ordinary atmospheric pressure, it enters into ebullition at 160° Fahr. A lighted taper brought near its surface at ordinary temperatures sets fire to it, and it burns with a yellowish-white flame. Acetic acid is developed in the combustion. It is not changed by keeping. Water at 62° dissolves a 7½ part of its weight. When thus dissolved in water, it exercises no action on litmus, and it preserves its characteristic odour and taste. But when this solution is put in contact with the half of its weight of caustic potash, its odour and taste disappear. It is now completely decomposed. Hence, if we submit this liquid to distillation, alcohol passes over, and acetate of potash remains. Acetic ether is, like all the others, very soluble in alcohol, and separable from alcohol by water. Its other properties are unknown. It is used only in medicine, as an exhilarant and diuretic.

Benzoic ether. The presence of a mineral acid is indispensable to *its* formation, as well as that of the remaining vegetable ethers.

Take 30 parts of benzoic acid, 60 of alcohol, 15 of strong muriatic acid. Introduce these ingredients mixed togther into a tubulated retort, and distil into a refrigerated receiver, stopping the operation when two-thirds have passed over. Atmospherical air, and traces of muriatic acid, are the only gaseous products. The first portion of the liquid is alcohol charged with a little acid, but the last will contain a certain quantity of benzoic ether, which is easily separable by water. A larger quantity of this ether remains in the retort, covered by a pretty thick stratum, consisting of alcohol, water, muriatic, and benzoic acids. By repeated affusions of hot water into the retort, this stratum will be finally dissolved. It is easy thus to procure benzoic ether. But as so made, it is always contaminated with a portion of benzoic acid, which renders it solid at ordinary temperatures, and makes it act on litmus. It may be purified by agitation with a small quantity of alkaline solution, and subsequent washing with water. There is no muriatic acid found in this purified ether.

Ethers from oxalic acid, citric, &c. When we make a solution of 30 parts of oxalic acid in 35 parts of pure alcohol, and having added 10 parts of oil of vitriol, we subject the whole to distillation till a little sulphuric ether begins to be formed, we shall find that nothing but alcohol slightly etherized has passed into the receiver, and there remains in the retort a brown coloured strongly acid liquor, from which, on cooling, crystals of oxalic acid fall down. But when we dilute the residual liquor with water, a matter is separated similar to what the benzoic acid yielded, scarcely soluble in water, very abundant, and which is obtained pure by washing it with cold water, and removing, by a little alkali, the excess of acid which it retains.

If we treat in the same way, the citric and malic acids, we obtain similar products. The three substances resulting from these three acids have analogous properties. They are all yellowish, somewhat heavier than water, void of smell, perceptibly soluble in water, and very soluble in alcohol, from which they are precipitated by water. They differ from each other in taste. That made from oxalic acid is faintly astringent; that from the citric acid is very bitter. The first is the only one which is volatile; it is vaporized with boiling water, and by this means it is easily obtained white. When heated with a solution of caustic potash, they are all three decomposed, and yield alcohol, along with their peculiar acids; but no trace of sulphuric acid.

Tartaric acid is also susceptible of combining with alcohol like the preceding acids. But it presents some curious phenomena. The experiment of its formation, must be conducted in the same way as with oxalic acid. We must employ 30 parts of tartaric acid, 35 of alcohol, 10 of oil of vitriol, and distil the mixture till a little sulphuric ether begins to be formed. If at this period we withdraw the heat from the retort, the liquor will assume a sirupy consistence by cooling. But in vain shall we pour in water, in hope of separating, as in the preceding cases, a peculiar combination of the vegetable acid and alcohol. But let us add by degrees solution of potash, we shall throw down much cream of tartar; then, after having just saturated the redundant acid, if we evaporate the liquid, and treat it in the cold with very pure alcohol, we shall obtain, by evaporation of the alcoholic solution, a substance which, on cooling, will become more sirupy than the matter was, before being treated with potash and alcohol. This substance, which is easily prepared in considerable quantity, has a brown colour, and a very bitter and slightly nauseous taste. It is void of smell and acidity, and is very soluble in water and alcohol. It does not precipitate muriate of lime, but copiously the muriate of barytes. When calcined it diffuses dense fumes, which have the odour of garlic, and at the same time it leaves a charcoaly residue, not alkaline, containing much sulphate of potash. Finally, if distilled with potash, it is resolved into a very strong alcohol, and much tartrate of potash. This substance is therefore a combination analogous to the preceding. But what is peculiar to it, is its sirupy state, and the property it possesses of rendering soluble in the most concentrated alcohol the sulphate of potash, which of itself is insoluble in ardent spirits. It is perhaps owing to this admixture of sulphate of potash, that it wants the oily aspect belonging to all the other combinations of this genus.

These vegetable-acid ethers may be considered either as compounds of acid and alcohol, or of the ultimate constituents of the former with those of the latter.*

Ethiops (Martial). Black oxide of iron.

Ethiops (Mineral). The black sulphuret of mercury.

Evaporation. A chemical operation usually performed by applying heat to any compound substance, in order to dispel the volatile parts. It differs from distillation in its object, which chiefly consists in preserving the more fixed matters, while the volatile substances are dissipated and lost. And the vessels are accordingly different, evaporation being commonly made in open shallow vessels, and distillation in an apparatus nearly closed from the external air.

The degree of heat must be duly regulated in evaporation. When the fixed and more volatile matters do not greatly differ in their tendency to fly off, the heat must be very carefully adjusted; but in other cases this is less necessary.

As evaporation consists in the assumption of the elastic form, its rapidity will be in proportion to the degree of heat and the diminution of the pressure of the atmosphere. A current of air is likewise of service in this process.

* In treating of alum, I alluded to a method of evaporating liquors lately introduced into large manufactories. A water-tight stone cistern, about three or four feet broad, two feet deep, and 20, 30, or 40 feet long, is covered above by a low brick arch. At one extremity of this tunnel a grate is built, and, at the other, a lofty chimney. When the cistern is filled, and a strong fire kindled in the reverberatory grate, the flame and hot air sweep along the surface of the liquor, raise the temperature of the uppermost stratum, almost instantly, to near the boiling point, and draw it off in vapour. The great extent, rapidity, and economy of this process, recommend it to general adoption on the great scale.

Mr. Barry has lately obtained a patent for an apparatus, by which vegetable extracts for the apothecary may be made at a very gentle heat and *in vacuo*. From these two circumstances, extracts thus prepared differ from those in common use, not only in their physical, but medicinal properties. The taste and smell of the extract of hemlock made in this way are remarkably different, as is the colour both of the soluble and feculent parts. The form of apparatus is as follows:—

The evaporating pan, or still, is a hemispherical dish of cast-iron, polished on its inner surface, and furnished with an air-tight flat lid. From the centre of this a pipe rises, and bending like the neck of a retort, it forms a declining tube, which terminates in a copper sphere of a capacity three (four?) times greater than that of the still. There is a stop-cock on that pipe, midway between the still and the globe, and another at the under side of the latter.

The manner of setting it to work is this: The juice, or infusion, is introduced through a large opening into the polished iron still, which is then closed, made air-tight, and covered with water. The stop-cock, which leads to the sphere, is also shut. In order to produce the vacuum, steam, from a separate apparatus, is made to rush, by a pipe, through the sphere, till it has expelled all the air, for which five minutes are commonly sufficient. This is known to be effected, by the steam issuing uncondensed. At that instant the copper sphere is closed, the steam shut off, and cold water admitted on its external surface. The vacuum thus produced in the copper sphere, which contains four-fifths of the air of the whole apparatus, is now partially transferred to the still, by opening the intermediate stop-cock. Thus, four-fifths of the air in the still rush into the sphere, and the stop-cock being shut again, a second exhaustion is effected by steam in the same manner as the first was; after which, a momentary communication is again allowed between the iron still and the receiver; by this means, four-fifths of the air remaining, after the former exhaustion, are expelled. These exhaustions, repeated five or six times, are usually found sufficient to raise the mercurial column to the height of 28 inches. The water bath, in which the iron still is immersed, is now to be heated, until the fluid that is to be inspissated begins to boil, which is known by inspection through a window in the apparatus, made by fastening on, air-tight, a piece of very strong glass; and the temperature at which the boiling point is kept up is determined by a thermometer. *Ebullition* is continued until the fluid is inspissated to the proper degree of consistence, which also is tolerably judged of by its appearance through the glass window. The temperature of the boiling fluid is usually about 100° F. but it might be reduced to nearly 90°.

In the sixth volume of the Annals of Philosophy, Dr. Prout has described an ingenious apparatus by means of which he can subject substances, which he wishes thoroughly to dry, to the influence of a gentle heat, conjoined with the desiccating power of sulphuric acid on bodies placed *in vacuo*. See Congelation.

From M. Biot's report, it seems to have been ascertained in some French manufactories, that evaporation goes on more rapidly from a liquid boiling in a covered vessel from the top of which a pipe issues, than when the liquid is freely exposed to the air; the fuel or heat applied, and extent of surface, being the same in both cases.*

Euchlorine. Protoxide of Chlorine.

Euclase. Prismatic Emerald.

Eudiometer. An instrument for ascertaining the purity of air, or rather the quantity of oxygen contained in any given bulk of elastic fluid. Dr. Priestley's discovery of the great readiness with which nitrous gas combines with oxygen, and is precipitated in the form of nitric acid, see Acid (nitric), was the basis upon which he constructed the first instrument of this kind.

His method was very simple: a glass vessel, containing an ounce by measure, was filled with the air to be examined, which was transferred from it to a jar of an inch and half diameter inverted in water; an equal measure of fresh nitrous gas was added to it; and the mixture was allowed to stand two minutes. If the absorption were very considerable, more nitrous gas was added, till all the oxygen appeared to be absorbed. The residual gas was then transferred into a glass tube two feet long, and one-third of an inch wide, graduated to tenths and hundredths of an ounce measure; and thus the quantity of oxygen absorbed was measured by the diminution that had taken place.

Von Humboldt proposes that the nitrous gas should be examined, before it is used, by agitating a given quantity with a solution of sulphate of iron.

Sir H. Davy employs the nitrous gas in a different manner. He passes it into a saturated solution of green muriate or sulphate of iron, which becomes opaque and almost black when fully impregnated with the gas. The air to be tried is contained in a small graduated tube, largest at the open end, which is introduced into the solution, and then gently inclined toward the horizon, to accelerate the action, which will be complete in a few minutes, so as to have absorbed all the oxygen. He observes, that the measure must be taken as soon as this is done, otherwise the bulk of the air will be increased by a slow decomposition of the nitric acid formed.

Volta had recourse to the accension of hydrogen gas. For this purpose, two measures of hydrogen are introduced into a graduated tube with three of the air to be examined, and fired by the electric spark. The diminution of bulk, observed after the vessel had returned to its original temperature, divided by three, gives the quantity of oxygen consumed.

Phosphorus and sulphuret of potash have likewise been employed in eudiometry.

A piece of phosphorus may be introduced by means of a glass rod into a tube containing the air to be examined standing over water, and suffered to remain till it has absorbed its oxygen; which, however, is a slow process. Or a glass tube may be filled with mercury and inverted, and a piece of phosphorus, dried with blotting paper, introduced, which will of course rise to the top. It is there to be melted, by bringing a red-hot iron near the glass, and the air to be admitted by little at a time. At each addition the phosphorus inflames; and, when the whole has been admitted, the red-hot iron may be applied again, to ensure the absorption of all the oxygen. In either of these modes 1-40th of the residuum is to be deducted, for the expansion of the nitrogen, by means of a little phosphorus which it affords.

Professor Hope of Edinburgh employs a very convenient eudiometer, when sulphuret of potash or Sir H. Davy's *liquid* is used. It consists of two glass vessels, one to hold the solution of sulphuret of potash, or other eudiometric liquor, about two inches in diameter, and three inches high, with a neck at the top as usual, and a tubulure, to be closed with a stopple in the side near the bottom: the other is a tube, about eight inches and a half long, with a neck ground to fit into that of the former. This being filled with the air to be examined, and its mouth covered with a flat piece of glass, is to be introduced under water, and there inserted into the mouth of the bottle. Taking them out of the water, and inclining them on one side, they are to be well shaken, occasionally loosening the stopper in a basin filled with water, so as to admit this fluid to occupy the vacuum occasioned by the absorption. Bottles of much smaller size than here mentioned, which is calculated for public exhibition, may generally be employed; and, perhaps, a graduated tube, ground to fit into the neck of a small phial, without projecting within it, may be preferable on many occasions, loosening it a little under water, from time to time, as the absorption goes on.

* Mr. Dalton has written largely on the nitrous gas eudiometer. He says, that 21 measures of oxygen can unite with 36 measures, or twice 36 = 72 measures, of nitrous gas; that is, 100 with 171.4 or 342.8. Phil. Mag. vol. xxiii. and Manch. Mem. new series, 1.

M. Gay-Lussac, in his excellent memoir on nitrous vapour and nitrous gas, has proved, that no confidence can be reposed in these directions of Mr. Dalton for analyzing gases. Nitrous gas is there fully demonstrated to be a compound of equal volumes of oxygen and azote, and the apparent contraction of their volume is null; for 100 of the one and 100 of the other produce exactly 200 of nitrous gas. *Nitric* acid is composed of 100 parts of azote, and 200 of oxygen, or of 100 oxygen and 200 nitrous gas; = (100 o. + 100 az.) Nitrous vapour, or, more accurately speaking, *nitrous* acid gas, results from the combination of 100 of oxygen with 300 of nitrous gas. Hence, by giving predominance alternately to the oxygen and to the nitrous gas, we obtain 300 of absorption and *nitric* acid, or 400 of absorption and *nitrous* acid. The nitrous acid gas is an identical compound, very soluble in water, which it colours at first blue, then green, and lastly orange-yellow. This liquid, with the alkalis, forms nitrites. These clear and simple facts contitute the whole theory of the formation of the nitrous and nitric acids, by means of nitrous gas and oxygen, and perfectly explain the differences of the results of all those who have operated with them. We have now only to show, how we may render the use of nitrous gas perfectly accurate in eudiometry.

It is stated above, that we obtain nitric acid and an absorption represented by three, or nitrous acid and a diminution of volume represented by four, every time, according as the oxygen or nitrous gas predominates in the mixture of these two gases. Now, since the object is to withdraw the whole oxygen from air, we must add the nitrous gas in excess to it, and cause thus a diminution of volume, four times greater than the volume of the contained oxygen. Notwithstanding this precaution, if we make the mixture in a very narrow tube, the nitrous vapour would be absorbed with difficulty by the water, on account of the narrow contact, and agitation would become necessary. But in this case, nitrous gas, to the amount of 10 or 12 per cent, would be absorbed. It is from this cause, that on mixing 100 parts of air with 100 of nitrous gas, very variable absorptions were obtained, of which the mean was 93; whilst air, containing at utmost 21 per cent of oxygen, the absorption should be only four times this quantity, or 84. Nor is it a matter of indifference, to put the nitrous gas in the tube before, or after the other gas; for if we introduce it first, there might be formed both nitrous and nitric acids. Knowing these two causes of error, it is easy to avoid them, by obeying the following injunctions of M. Gay-Lussac.

Instead of selecting a very narrow tube, as Mr. Dalton prescribed, we must take a very wide tube, a tumbler for example, and after having introduced into it 100 of the air to be examined, we must pass into it 100 parts of the nitrous gas. There is instantly exhibited a red vapour, which disappears very speedily without agitation, and after half a minute, or a minute at most, the absorption may be regarded as complete. We transfer the residuum into a graduated tube, and we shall find the absorption to be almost uniformly 84 parts, provided atmospheric air was used, one-fourth of which = 21, indicates the quantity per cent of oxygen.

M. Gay-Lussac shows, by numerous experiments, the accuracy of the above process, in varied circumstances. We have thus the advantage of estimating the proportion of oxygen in any gas, by an absorption four times greater than its own volume; so that the errors of experiment are reduced to one-fourth, on the quantity of oxygen. Now, as we can never commit a mistake of four degrees, the error must be less than one per cent. We must never agitate, or use an under proportion of nitrous gas, nor yet carry its excess too far, on account of its solubility in water.

An apparatus for analyzing gases containing oxygen or chlorine, by explosion with hydrogen, was communicated by me to the Royal Society of Edinburgh, and published in the volume of their Transactions for 1817 and 1818.

Description of an Apparatus for the Analysis of Gaseous Matter by Explosion. By Dr. Ure.

The analysis of combustible gases, and supporters of combustion, reciprocally, by explosion, with the electric spark, furnishes, when it can be applied, one of the speediest and most elegant methods of chemical research. The risk of failure to which the chemist is exposed, in operating with the simple tube, from the ejection of the mercury, and escape or introduction of the air; or of injury from the bursting of the glass, by the forcible expansion of some gaseous mixtures, has given rise to several modifications of apparatus.

Volta's mechanism, which is employed very much at Paris, is complex and expensive,§ while it is hardly applicable to experiments over mercury. Mr. Pepys' ingenious contrivance, in which the glass tube is connected with a metallic spring, to diminish the shock of explosion, is liable also to some of the above objections.

A very simple form of instrument occurred to me about two years ago, in which the atmospheric air, the most elastic and economical of all springs, is employed to receive and deaden the recoil. Having frequently used it since that time, I can now recommend it to the chemical world, as possessing every requisite advantage of convenience, cheapness, safety, and precision.

It consists of a glass syphon, having an interior diameter of from 2-10ths to 4-10ths of an inch. Its legs are of nearly equal length, each being from six to nine inches long. The open extremity is slightly funnel-shaped, the other is hermetically sealed; and has inserted near it, by the blowpipe, two platina wires. The outer end of the one wire is incurvated across, so as nearly to touch the edge of the aperture; that of the other is formed into a little hook, to allow a small spherical button to be attached to it, when the electrical spark is to be transmitted. The two legs of the syphon are from one-fourth to one-half inch asunder.

The sealed leg is graduated, by introducing successively equal weights of mercury from a measure glass tube. Seven ounces troy and 66 grains, occupy the space of a cubic inch; and 34¼ grains represent $\frac{1}{100}$ part of that volume. The other leg may be graduated also, though this is not necessary. The instrument is then finished.

To use it, we first fill the whole syphon with mercury or water, which a little practice will render easy. We then introduce into the open leg, plunged into a pneumatic trough, any convenient quantity of the gases, from a glass measure tube, containing them previously mixed in determinate proportions. Applying a finger to the orifice, we next remove it from the trough in which it stands, like a simple tube; and by a little dexterity, we transfer the gas into the sealed leg of the syphon. When we conceive enough to have been passed up, we remove the finger, and next bring the mercury to a level in both legs, either by the addition of a few drops, or by the displacement of a portion, by thrusting down into it a small cylinder of wood. We now ascertain, by careful inspection, the volume of included gas. Applying the fore-finger again to the orifice, so as also to touch the end of the platina wire, we then approach the pendent ball or button to the electrical machine, and transmit the spark. Even when the included gas is considerable in quantity, and of a strongly explosive power, we feel at the instant nothing but a slight push or pressure on the tip of the finger. After explosion, when condensation of volume ensues, the finger will feel pressed down to the orifice by the superincumbent atmosphere. On gradually sliding the finger to one side, and admitting the air, the mercurial column in the sealed leg will rise more or less above that in the other. We then pour in this liquid metal, till the equilibrium be again restored, when we read off as before, without any reduction, the true resulting volume of gas.

As we ought always to leave two inches or more of air, between the finger and the mercury, this atmospheric column serves as a perfect recoil spring, enabling us to explode very large quantities without any inconvenience or danger. The manipulation is also, after a little practice, as easy as that of the single tube. But a peculiar advantage of this detachable instrument is, to enable us to keep our pneumatic troughs, and electrical machine, at any distance which convenience may require; even in different chambers, which, in the case of wet weather, or a damp apartment, may be found necessary to ensure electrical excitation. In the immediate vicinity of the water pnuematic cistern, we know how often the electric spark refuses to issue from a good electrophorus, or even little machine. Besides, no discharging rod or communicating wire is here required. Holding the eudiometer in the left hand, we turn the handle of the machine, or lift the electrophorus plate with the right, and approaching the little ball, the explosion ensues. The electrician is well aware, that a spark so small as to excite no unpleasant feeling in the finger, is capable, when drawn off by a smooth ball, of inflaming combustible gas. Even this trifling circumstance may be obviated, by hanging on a slender wire, instead of applying the finger.

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§ The price of the apparatus is three guineas.

We may analyse the residual gaseous matter, by introducing either a liquid or a solid reagent. We first fill the open leg nearly to the brim with quicksilver, and then place over it the substance whose action on the gas we wish to try. If liquid, it may be passed round into the sealed leg among the gas; but if solid, fused potash, for example, the gas must be brought round into the open leg, its orifice having been previously closed with a cork or stopper. After a proper interval, the gas being transferred back into the graduated tube, the change of its volume may be accurately determined. With this eudiometer, and a small mercurial pneumatic cistern, we may perform pneumatic analyses on a very considerable scale.

It may be desirable in some cases, to have ready access to the graduated leg, in order to dry it speedily. This advantage is obtained, by closing the end of the syphon, not hermetically, but with a little brass cap screwed on, traversed vertically by a platina wire insulated in a bit of thermometer tube. After the apparatus has been charged with gas for explosion, we connect the spherical button with the top of the wire.

With the above instrument I have exploded half a cubic inch of hydrogen mixed with a quarter of a cubic inch of oxygen; as also, a bulk nearly equal of an olefiant gas explosive mixture, without any unpleasant concussion or noise; so completely does the air-chamber abate the expansive violence, as well as the loudness of the report. Projection of the mercury, or displacement of the gas, is obviously impossible. *Edin. Phil. Trans. January* 1818.*

† *Account of New Eudiometers, invented by* ROBERT HARE, *M. D. Professor of Chemistry, &c. in the Medical Department of the University of Pennsylvania.*

Among the operations of chemistry, none probably are more difficult than those called eudiometrical, in which aeriform substances are analyzed.

Elastic fluids are so liable to contract or expand with the slightest change of temperature or pressure, that it is requisite to have the surface of the portion under admeasurement exactly in the same level with that of the water or mercury employed to confine it, and the heat of the hand may render the result inaccurate. There is no simple mode of causing the surface of the gas in a measure glass to form a plane corresponding with the brim. The transfer of small portions of gas without loss, especially from large bells into small tubes is very difficult. Hence there is trouble, delay and waste.

I shall proceed to describe some instruments which I have lately invented, and which appear to be free from the disadvantages above described. They are all essentially dependent on one principle for their superiority.§

A recurved glass tube is furnished with a sliding wire of iron or copper, graduated into two hundred parts. The process of making wire by drawing it through a hole, renders its circumferences of necessity every where equal and homologous. Consequently equal lengths will contain equal bulks.

The wire slides through a cork soaked in bees-wax and oil, and compressed by a screw, so that neither air nor water can pass by it.

The length of the longer leg is fifteen inches, that of the shorter one six inches. The bore of the tube is from $\frac{4}{10}$ to $\frac{5}{10}$ of an inch in diameter, but converges towards the termination of the shorter leg to an orifice about large enough to admit a brass pin. Over this a screw is sometimes affixed so as to close it when necessary.

The tube being filled with water or mercury, and the wire pushed into it as far as it can go, on drawing this out again any desired distance, an equivalent bulk of air must enter the capillary orifice if open. By forcing the rod back again into the tube, the air must be proportionably excluded. Thus the movements of the sliding wire are accompanied by a corresponding ingress or egress of air; and to know how many divisions of the former have been pushed into the tube or withdrawn from it, is the same as to know how much air has been drawn in or expelled.

If instead of allowing the orifice to be in the open air, it be introduced within a bell glass, holding gas over the pneumatic apparatus, on pulling out the wire, there will be a corresponding entrance of gas into the instrument; and it must be evident that if the point of the gas measurer be transferred to the interior of any other recipient, the gas which had entered, or any part of it may be made to go into any such recipient by reversing the motion of the wire. As the hands are, during this operation, remote from the part of the tube which contains the aeriform matter, no expansion can arise from this source, and the operation is so much expedited that there is much less chance of variation from any other cause. By taking care to have the surface of the gas in the bell glasses below that of the fluid in the cistern, the density of the former will be somewhat too great, but on bringing the orifice of the gas measurer on a level with the surface of the fluid in the cistern, the gas no longer subject to any extra pressure, will assume its proper volume, the excess being seen to escape in bubbles. Should the tube, in lieu of water, be filled with any solution, calculated to absorb any gas, of which the proportion, in any mixture is to be ascertained, and if the quantity of absorption which can take place while the wire is drawing out, is deemed unworthy of attention, we have only to introduce the shorter leg of the tube into the containing vessel, as above described, and draw out the wire to two hundred on its scale; then depressing the point below the surface of the fluid in the pneumatic cistern, in the usual time with due agitation, all the gas which the fluid can take up, will disappear. The quantity will be represented by the number of divisions which remain without the tube, after pushing in the wire just so far as to exclude the residual gas.

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§ See the plate at the end of the work.

Should it be deemed an object to avoid the possibility of any absorption during the time occupied in the retraction of the sliding wire, or should it be desired to expose the gas to a large quantity of the absorbing fluid, an additional vessel is used, which is of an oblate spheroidal form, with a large neck ground to fit the shorter leg of a gas measurer, and furnished at the opposite apex with a tube, of which the bore converges to a capillary opening, surmounted by a screw, as already described, on the point of the gas measurer simply. This vessel (in shape not unlike a turnip) is filled with the absorbing fluid, and the gas measure, being duly charged with gas as above described, inserted into it. By the action of the sliding wire, the gas is propelled into the spheroid, where by agitation and time the absorption is completed. Meanwhile the orifice of the spheroid should be kept open, and under water, so as to permit the latter to take place of that portion of the gas which disappears.—Whatever remains unabsorbed, is expelled from the glass spheroid, as in the case of the tube when used alone; and the divisions on the rod remaining without, will show how much the fluid has taken up.

When atmospheric air, or oxygen gas is to be analyzed by nitrous gas, the glass spheroid is filled with water, and inverted with its orifice closed over the well of the pneumatic cistern. It should be supported by a wire stand, so as to leave the neck unobstructed. Any number of measures of nitrous gas, and of oxygen gas, or atmospheric air, may then be drawn into the measurer, and expelled into the spheroid successively, and the absorption estimated as already explained. When the residuum is too great to be expelled by returning the whole of the rod into the tube; by depressing the orifice of the spheroid just under the surface of water, the wire may be again gently retracted, water taking its place; and the movement may thus be alternated, till the whole of the remaining gas is excluded.

In order to apply this principle to Volta's process of ascertaining by explosion the quantity of hydrogen or oxygen gas present in a mixture, the gas measurer is made as much stronger, as eudiometers are usually, when intended to be so used. It is in like manner drilled so as to receive wires for passing the electric spark. The instrument being charged with the gases successively in any required proportion, closed by the screw, and an explosion accomplished; to fill any consequent vacuity, the orifice is to be opened just below the surface of water or mercury. The quantity destroyed by the combustion is then ascertained by the sliding wire.

This experiment is more accurately performed by means of mercury than water. From this fluid, concussion, or even the partial vacuum produced by the gaseous matter, may extricate air, and thus vitiate results. There ought always to be a considerable excess of gas not liable to be acted on. The activity of the inflammation is lessened, and the unconsumed air breaks the shock.

I have found the galvanic ignition produced by a small calorimotor preferable to the electric spark. Suppose a piece of iron to be filed down in the middle for about one half of an inch to about one third of the original diameter. The whole is cemented into the perforation drilled in the tube, so as that the smallest part may extend across the bore. The wire should then be cut off at about one third of an inch from the tube, so as to stand out from it on each side about that distance. If these protruding wires be severally placed in the forceps of a calorimotor and the plates subjected to an acid, the small part of the wire within the tube is vividly ignited, and any gas in contact with it must explode. The interior wire is best made of platina, and may in that case be screwed into two larger pieces of a baser metal: or baser metal may be fastened on it, by drawing through a wire plate, and the platina duly denuded by a file where it crosses the bore.

The calorimotor which I have used for this purpose, consists of eleven plates of copper, and a like number of zinc placed alternately within one-fourth of an inch of each other: those of the same kind of metal being all associated by means a metallic stratum of tin cast over them. The two heterogeneous galvanic surfaces thus formed, have each soldered to them a wire in a vertical position, and slit, so as to present a fork or snake's mouth. The wires are just so far apart as to admit the gas measurer between them, and so that the wires of the latter may easily be pressed into the snake mouths. It is better that the wires of the gas measurer should be flattened in such manner as to present a larger surface for contact. There must also be an oblong square box or hollow parallelopipedon of such a width as just to admit the calorimotor, and more than double its length and depth. The calorimotor is placed within this box, at one end of it, about an inch below the brim. Diluted acid is poured so as to occupy the lower half of the vessel, until it nearly reaches the plates. A plunger, consisting of a water tight box, or solid block of wood, is then made to occupy the other side of the little cistern. The depression of this causes the rise of the acid among the plates in the calorimotor, and consequently the ignition of a wire forming a communication between the surfaces.

This apparatus may be constructed in the circular form, by so placing two concentric coils, or several concentric hollow cylinders of copper and zinc, alternately within the upper half of a glass jar as to admit of a plunger in the middle, which in this case may be of an apothecary's stopper round or bottle. The acid solution must occupy the lower half of the vessel, unless when the plunger raises it.

I am under the impression that there is no form in which a pair of galvanic surfaces can be made so powerful in proportion to their extent, as in the above mentioned. The zinc is every where opposed by two copper surfaces by having this metal only a small fraction in excess.

Explanation of the plate. (*See the end of the work.*)

Fig. 1. Sliding rod eudiometer or gas measurer, surmounted by its spheroidal recipient. r r, sliding rod graduated into twenty divisions, each subdivided into ten, so as to make two hundred parts. At m f, are male and female screws, (forming what mechanics call a stuffing box), by means of which a cork soaked in bees-wax and oil is compressed around the rod. At n, is the neck of the recipient, ground to fit the recurved tube which enters it. At S, is a screw, by which to close the capillary orifice of the recipient.

Fig. 2. Eudiometer upon the same principle, but made stouter in order to resist the explosion of inflammable mixtures. W W, wire to be ignited.

Fig. 3. Displays a construction of the sliding rod, by which when desirable, greater accuracy may be attained in the measurement of gas. A smaller rod of wire is made to slide within the larger. Whatever may be the ratio (in bulk) of the rods to each other, the lesser may be graduated to give thousandths, by ascertaining how far it must be moved to produce the effect of a movement of one division on the large rod, and dividing the observed distance into ten parts.

Fig. 4. Represents an apparatus adapted to explode an inflammable mixture, as mentioned in the preceding article, and so contrived as to be a substitute for the well known apparatus in which an electrophorus is employed to ignite hydrogen gas. Moisture in the air suspends the action of that apparatus but does not interfere with the one here represented.

A A, a cistern divided by a water-tight partition, which separates the holder G, from a calorimotor situated under C, and a plunger P, contained in the other part of it. W W, wires severally soldered to the different galvanic surfaces, and forked or slit at their ends, so as to embrace the wire of an eudiometer for the explosion of inflammable mixtures, as mentioned in the preceding article. At f f, are forceps (severally soldered in the same way) for holding a wire to be ignited by the galvanic influence.

These wires and the plates with which they are connected may be seen at fig. 5, where there is an enlarged drawing of the calorimotor and its wires.

It is supposed to be situated below the edge of the cistern which is supplied with diluted acid reaching within a little distance of the plates.

c, a cock soldered to a pipe communicating with the inside of the gasometer. h h, a gallows and guide wire, for regulating the rise of the gasometer.

The construction of this will be better comprehended from fig. 6, where it represents the tray for holding the zinc, by means of which hydrogen is to be evolved. The tray is supported on the pipe in the axis of the vessel by a sliding band and screw, so that it may be raised or depressed at pleasure. When this tray is covered with granulated zinc, and the lower vessel is filled with acid so as to cover it, hydrogen must be generated until it occupies so much of the air-holder, as to depress the acid from off the zinc. Supposing the apparatus thus prepared, on depressing the plunge P, fig. 4, the acid in the cistern A A, will be forced up among the galvanic surfaces, and cause the wire at f f, to be ignited. Turning the cock while the wire is red-hot, the hydrogen will be emitted and inflamed.†

Euphorbium. A gum-resin exuding from a large oriental shrub, Euphorbia officin. Linn.

It is brought to us immediately from Barbary, in drops of an irregular form; some of which upon being broken are found to contain little thorns, small twigs, flowers, and other vegetable matters; others are hollow, without any thing in their cavity: the tears in general are of a pale yellow colour externally, somewhat white withinside; they easily break betwixt the fingers. Sp. gr. 1.124. Slightly applied to the tongue, they affect it with a very sharp biting taste; and, upon being held for some time in the mouth, prove vehemently acrimonious, inflaming and exulcerating the fauces, &c. Euphorbium is extremely troublesome to pulverize, the finer part of the powder, which flies off, affecting the head in a violent manner. The acrimony is so great, as to render it absolutely unfit for any internal use. It is much employed in the veterinary art as an epispastic:

* The following constituents were found in Euphorbium by Braconnot:

Resin,	37.0
Wax,	19.0
Malate of lime,	20.5
Malate of potash,	2.0
Water,	5.0
Woody matter,	13.5
Loss,	3.0
	100.0

The resin is excessively acrid, poisonous, reddish-coloured, and transparent. It dissolves in sulphuric and nitric acids, but not in alkalis, in which respect it differs from other resins. Euphorbium itself is pretty soluble in alcohol.*

* **Excrements.** The constituents of human feces, according to the recent analysis of Berzelius, are the following:

Water,	73.3
Vegetable and animal remains,	7.0
Bile,	0.9
Albumen,	0.9
Peculiar extractive matter,	2.7
Salts,	1.2
Slimy matter, consisting of picromel, peculiar animal matter, and insoluble residue,	14.0
	100.0

The salts were to one another in the following proportions:

Carbonate of soda,	0.9
Muriate of soda,	0.1
Sulphate of soda,	0.05
Ammon. phos. magn.	0.05
Phosphate of lime,	0.1
	1.20

Thaer and Einhof obtained, by ignition, from 3840 grains of the excrements of cattle, fed at the stall chiefly on turnips, the following earths and salts:

Lime,	12,
Phosphate of lime,	12.5
Magnesia,	2.0
Iron,	5.0
Alumina with some manganese,	14.0
Silica,	52.0
Muriate and sulphate of potash,	1.2
	98.7*

Expansion. See Caloric.

Extract. When decoction is carried to such a point as to afford a substance either solid or of the consistence of paste, this residual product is called an extract. When chemists speak of extract, they most commonly mean the product of aqueous decoction; but the earlier chemists frequently speak of spirituous extract.

Extracts thus prepared are mixtures of several of the materials of vegetables, whence they differ greatly, according to the plants from which they are obtained; but modern chemists distinguish by the name of extract, or *extractive matter*, a peculiar substance, supposed to be one of the immediate materials of vegetables, and the same in all, when separated from any foreign admixture, except as the proportion of its constituent principles may vary. See Evaporation.

Eye. The humours of the eye had never been examined with any degree of accuracy till lately by M. Chenevix. Most of his experiments were made with the eyes of sheep, as fresh as they could be procured.

The aqueous humour is a clear, transparent liquid, with little smell or taste, and at the temperature of 60°, its specific gravity is 1.009. It consists of water, albumen, gelatin and muriate of soda.

The crystalline contains a much larger proportion of water, and no muriate. Its specific gravity is 1.1.

The vitreous humour, when pressed through a rag to free it from its capsules, differed in nothing from the aqueous, either in its specific gravity or chemical nature.

Fourcroy mentions a phosphate as contained in these humours, but M. Chenevix could discover none.

The humours of the human eye gave the same products, but the specific gravity of the crystalline was only 1.079, and that of the aqueous and vitreous humours 1.0053.

The eyes of oxen differed only in the specific gravity of the parts, that of the crystalline being 1.0765, and that of the other humours 1.0088.

The specific gravity of the crystalline is not equal throughout, its density increasing from the surface to the centre. —*Phil. Trans.* 1803.

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* **FAHLUNITE.** *Automalite*, a sub-species of octohedral corundum.*

FARINA. Vegetable flour.

* **FAT.** Concerning the nature of this important product of animalization, nothing definite was known, till M. Chevreul devoted himself with meritorious zeal and perseverance to its investigation. He has already published in the Annales de Chimie, seven successive memoirs on the subject, each of them surpassing its predecessor in interest. We shall in this article give a brief abstract of the whole.

By dissolving fat in a large quantity of alcohol, and observing the manner in which its different portions were acted upon by this substance, and again separated from it, it is concluded that fat is composed of an *oily substance*, which remains fluid at the ordinary temperature of the atmosphere; and of another *fatty substance*, which is much less fusible. Hence it follows, that fat is not to be regarded as a simple principle, but as a combination of the above two principles, which may be separated without alteration. One of these substances melts at about 45°, the other at 100°; the same quantity of alcohol which dissolves 3.2 parts of the *oily substance*, dissolves 1.8 only of the *fatty substance*; the first is separated from the alcohol in the form of an oil; the second in that of small silky needles. See ELAÏN.

Each of the constituents of natural fat was then saponified by the addition of potash; and an accurate description given of the compounds which were formed, and of the proportions of their constituents. The *oily substance* became saponified more readily than the *fatty substance*; the residual fluids in both cases contained the sweet oily principle; but the quantity that proceeded from the soap formed of the *oily substance*, was four or five times as much as that from the *fatty substance*; the latter soap was found to contain a much greater proportion of the *pearly matter* than the former, in the proportion of 7.5 to 2.9; the proportion of the *fluid fat* was the reverse, a greater quantity of this being found in the soap formed from the oily substance of the fat.

When the principles which constitute fat unite with potash, it is probable that they experience a change in the proportion of their elements; this change developes at least three bodies, *margarine*, *fluid fat*, and *the sweet principle*; and it is remarkable, that it takes place without the absorption of any foreign substance, or the disengagement of any of the elements which are separated from each other. As this change is effected by the intermedium of the alkali, we may conclude that the newly formed principles must have a strong affinity for salifiable bases, and will in many respects resemble the acids; and, in fact, they exhibit the leading characters of acids in reddening litmus, in decomposing the alkaline carbonates to unite to their bases, and in neutralizing the specific properties of the alkalis.

Having already pointed out the analogy between the properties of acids and the principles into which fat is converted by means of the alkalis, the next object was to examine the action which other bases have upon fat, and to observe the effect of water, and of the cohesive force of the bases upon the process of saponification. The substances which the author subjected to experiment, were soda, the four alkaline earths, alumina, and the oxides of zinc, copper, and lead. After giving a detail of the processes which he employed with these substances respectively, he draws the following general conclusions:—Soda, barytes, strontian, lime, the oxide of zinc, and the protoxide of lead, convert fat into *margarine*, *fluid fat*, *the sweet principle*, *the yellow colouring principle*, and *the odorous principle*, precisely in the same manner as potash. Whatever be the base that has been employed, the products of saponification always exist in the same relative proportion. As the above mentioned bases form with margarine and the fluid fat, compounds which are insoluble in water, it follows, that the action of this liquid, as a solvent of soap, is not essential to the process of saponification. It is remarkable that the oxides of zinc and of lead, which are insoluble in water, and which produce compounds equally insoluble, should give the same results with potash and soda, a circumstance which proves that those oxides have a strong alkaline power. Although the analogy of magnesia to the alkalis is, in other respects, so striking, yet we find that it cannot convert fat into soap under the same circumstances with the oxides of zinc and lead.

It was found that 100 parts of hog's lard were reduced to the completely saponified state by 16.36 parts of potash. See Elaïn and Acid (Margaric).

The properties of spermaceti were next examined: it melts at about 112°; it is not much altered by distillation; it dissolves readily in hot alcohol, but separates as the fluid cools; the solution has no effect in changing the colour of the tincture of litmus, a circumstance, as it is observed, in which it differs from margarine, a substance which, in many respects, it resembles. Spermaceti is capable of being saponified by potash, with nearly the same phenomena as when we submit hog's-lard to the action of potash, although the operation is effected with more difficulty.

The author's general conclusion respecting the fatty matter of dead bodies is, that even after the lactic acid, the lactates, and other ingredients, which are less essential, are removed from it, it is not a simple, ammoniacal soap, but a combination of various fatty substances with ammonia, potash, and lime. The fatty substances which were separated from alcohol, had different melting points and different sensible properties. It follows, from M. Chevreul's experiments, that the substance which is the least fusible, has more affinity for bases than those which are more so. It is observed, that adipocere possesses the characters of a saponified fat; it is soluble in boiling alcohol in all proportions, reddens litmus, and unites readily to potash, not only without losing its weight, but without having its fusibility or other properties changed.

M. Chevreul has shown, that hog's-lard, in its natural state, has not the property of combining with alkalis; but that it acquires it by experiencing some change in the proportion of its elements. This change being induced by the action of the alkali, it follows that the bodies of the new formation must have a decided affinity for the species of body which has determined it. If we apply this foundation of the theory of saponification to the change into fat, which bodies buried in the earth experience, we shall find that it explains the process in a very satisfactory manner. In reality the fatty matter is the combination of the two adipose substances with ammonia, lime, and potash; one of these substances has the same sensible properties with margarine procured from the soap of hog's-lard; the other, the orange-coloured oil, excepting its colour, appears to have a strong analogy with the fluid fat. From these circumstances, it is probable that the formation of the fatty matter may be the result of a proper saponification produced by ammonia, proceeding from the decomposition of the muscle, and by the potash and lime, which proceed from the decomposition of certain salts.

The author remarks, that he has hitherto made use of periphrases when speaking of the different bodies that he has been describing, by supposing that their nature was not sufficiently determined. He now, however, conceives, that he may apply specific names to them, which will both be more commodious, and, at the same time, by being made appropriate, will point out the relation which these bodies bear to each other. The following is the nomenclature which he afterwards adopted:—The crystalline matter of human biliary calculi is named *cholesterine*, from the Greek words χολη bile, and ϛερεος solid; spermaceti is named *cetin*, from κητος, a whale; the fatty substance and the oily substance are named respectively, *stearin* and *elain*, from the words ϛεαρ fat, and ελαιον oil; margarine and the fluid fat obtained after saponification, are named *margaric acid* and *oleic acid*, while the term *cetic acid*, is applied to what was named saponified spermaceti. The *margarates*, *oleates* and *cetates* will be the generic names of the soaps or combinations, which these acids are capable of forming by their union with salifiable bases.

Two portions of human fat were examined, one taken from the kidney, the other from the thigh; after some time they both of them manifested a tendency to separate into two distinct substances, one of a solid, and the other of a fluid consistence; the two portions differed in their fluidity and their melting point. These variations depend upon the different proportions of stearin and elaïn; for the concrete part of fat is a combination of the two with an excess of stearin, and the fluid part is a combination with an excess of elaïn. The fat from the other animals was then examined, principally with respect to their melting point and their solubility in alcohol; the melting point was not always the same in the fat of the same species of animal. When portions of the fat of different sheep are melted separately at the temperature of 122°, in some specimens the thermometer descends to 98.5°, and rises again to 102°, while in others it descends to 104°, and rises again to 106°. A thermometer plunged into the fat of the ox melted at 122°, descended to 98.5°, and rose again to 102°. When the fat of the jaguar was melted at 104°, the thermometer descended to 84°, and rose again to about 85°; but a considerable portion of the fat still remained in a fluid state. With respect to the solubility of the different kinds of fat in alcohol, it was found that 100 parts of it dissolved 2.48 parts of human fat, 2.26 parts of sheep's fat, 2.52 parts of the fat of the ox, 2.18 parts of the fat of the jaguar, and about 2.8 parts of the fat of the hog.

M. Chevreul next examines the change which is produced in the different kinds of fat respectively by the action of potash. All the kinds of fat are capable of being perfectly saponified, when excluded from the contact of the air; in all of them there was the production of the saponified fat and the sweet principle; no carbonic acid was produced, and the soaps formed contained no acetic acid, or only slight traces of it. The saponified fats had more tendency to crystallize in needles than the fats in their natural state; they were soluble in all proportions in boiling alcohol of the specific gravity of 0.821. The solution, like that of the saponified fat of the hog, contained both the margaric and the oleic acids. They were less fusible than the fats from which they were formed; thus, when human fat, after being saponified, was melted, the thermometer became stationary at 95°, when the fluid began to congeal; in that of the sheep, the thermometer fell to 118.5°, and rose to 122°; in that of the ox it remained stationary at 118.5°; and in that of the jaguar at 96.5°.

The saponified fat of the sheep and the ox, had the same degree of solubility in potash and soda, as that of the hog.

100 parts of the fat of the sheep when saponified were dissolved by	15.41 of potash.
100 parts of the same were dissolved by	10.27 of soda.
100 parts of the saponified fat of the ox were dissolved by	15.42 of potash.
100 parts of the same were dissolved by	10.24 of soda.
100 parts of the saponified fat of the hog were dissolved by	15.04 of potash.
100 parts of the same were dissolved by	10.29 of soda.

The following table contains the proportions of the saponified fat, and of the matter soluble in water, into which 100 parts of the fat are capable of being changed:—

Human fat.	
Saponified fat,	95
Soluble matter,	5
Fat of the sheep.	
Saponified fat,	95.1
Soluble matter,	4.9
Fat of the ox.	
Saponified fat,	95
Soluble matter,	5
Fat of the hog.	
Saponified fat,	94.7
Soluble matter,	5.3

M. Chevreul next gives an account of the analysis of fat by alcohol.

The method of analysis employed was to expose the different kinds of fat to boiling alcohol, and to suffer the mixture to cool; a portion of the fat that had been dissolved was then separated in two states of combination; one with an excess of stearin was deposited, the other with an excess of elaïn remained in solution. The first was separated by filtration; and by distilling the filtered fluid, and adding a little water towards the end of the operation, we obtain the second in the retort, under the form of an alcoholic aqueous fluid. The distilled alcohol which had been employed in the analysis of human fat had no sensible odour; the same was the case with that which had served for the analysis of the fat of the ox, of the hog, and of the goose. The alcohol which had been employed in the analysis of the fat of the sheep, had a slight odour of candle-grease.

The varieties of stearin from the different species of fat, were found to possess the following properties:—They were all of a beautiful white colour; entirely, or almost without odour, insipid, and having no action upon litmus.—*Stearin from man.* The thermometer which was plunged into it when melted fell to 105.5°, and rose again to 120°. By cooling, the stearin crystallized in very fine needles, the surface of which was flat.—*Stearin of the sheep.* The thermometer fell to 104°, and rose again to 109.5°; it formed itself into a flat mass; the centre, which cooled more slowly than the edges, presented small and finely radiated needles.—*Stearin of the ox.* The thermometer fell to 103°, and rose again 111°; it formed itself into a mass, the surface of which was flat, over which were dispersed a number of minute stars, visible by the microscope; it was slightly semi-transparent.—*Stearin of the hog.* It exhaled the odour of hog's-lard when it was melted. The thermometer fell to 100.5°, and rose again to 109.5°. By cooling, it was reduced into a mass, the surface of which was very unequal, and which appeared to be formed of small needles. When it cooled rapidly, the parts which touched the sides of the vessel had the semi-transparency of coagulated albumen.—*Stearin of the goose.* The thermometer fell to 104°, and rose again to 109.5°; it was formed into a flat mass.

With respect to the solubility of these different bodies in alcohol, 100 parts of boiling alcohol, of the specific gravity of 0.7952, dissolved,

Of human stearin,	21.50 parts.
Of the stearin of the sheep,	16.07
Of the stearin of the ox,	15.48 parts.
Of the stearin of the hog,	18.25
Of the stearin of the goose,	36.00

Saponification by potash.

The human stearin produced, by saponification,	Saponified fat, 94.9	It was fusible at 123.5°; it crystallized in small needles joined in the form of a funnel.
	Soluble matter, 5.1	The sirup of the sweet principle weighed 8.6, the acetate 0.3.§
Stearin of the sheep.	Saponified fat, 94.6	It began to become opaque at 129°, and the thermometer became stationary at 127.5°; it crystallized in small fine radiated needles.
	Soluble matter, 5.4	The sirup of the sweet principle weighed 8, the acetate 0.6; it had a rancid odour.
Stearin of the ox.	Saponified fat, 95.1	It began to become solid at 129°, but it was not perfectly so until 125.5°; it crystallized in small needles united into flattened globules.
	Soluble matter, 4.9	The sirup of the sweet principle weighed 9.8, the acetate 0.3.
Stearin of the hog.	Saponified fat, 94.65	It began to grow solid at 129°, and the thermometer became stationary at 125.5°; it crystallized in small needles united into flattened globules.
	Soluble matter, 5.35	The sirup of the sweet principle weighed 9, the acetate 0.4.
Stearin of the goose.	Saponified fat, 94.4	It became solid at 119°; it crystallized in needles united in the form of a funnel.
	Soluble matter, 5.6	The sirup of the sweet principle weighed 8.2.

All the soaps of stearin were analyzed by the same process as the soap of the fat from which they had been extracted; there was procured from them the pearly super-margarate of potash and the oleate; but the first was much more abundant than the second. The margaric acid of the stearins had precisely the same capacity for saturation as that which was extracted from the soaps formed of fat. The margaric acid of the stearin of the sheep was fusible at 144°, and that of the stearin of the ox at 143.5°, while the margaric acids of the hog and the goose had nearly the same fusibility with the margaric acid of the fat of these animals.

On Spermaceti; or, as M. Chevreul technically calls it, *cetin*. In the fifth memoir, in which we have an account of many of the properties of this substance, it was stated, that it is not easily saponified by potash, but that it is converted by this reagent into a substance which is soluble in water, but has not the saccharine flavour of the sweet principle of oils; into an acid analogous to the margaric, to which the name of *cetic* was applied; and into another acid, which was conceived to be analogous to the oleic. Since he wrote the fifth memoir, the author has made the following observations on this subject:—1. That the portion of the soap of cetin which is insoluble in water, or the cetate of potash, is in part gelatinous, and in part pearly: 2. That two kinds of crystals were produced from the cetate of potash which had been dissolved in alcohol: 3. That the cetate of potash exposed, under a bell glass, to the heat of a stove, produced a sublimate of a fatty matter which was not acid. From this circumstance M. Chevreul was led to suspect, that the supposed cetic acid might be a combination, or a mixture of margaric acid and of a fatty body which was not acid; he accordingly treated a small quantity of it with barytic water, and boiled the soap which was formed in alcohol; the greatest part of it was not dissolved, and the alcoholic solution, when cooled, filtered, and distilled, produced a residuum of fatty matter which was not acid. The suspicion being thus confirmed, M. Chevreul determined to subject cetin to a new train of experiments. Being treated with boiling alcohol, a cetin was procured which was fusible at 120°, and a yellow fatty matter which began to become solid at 89.5°, and which at 73.5°, contained a fluid oil, which was separated by filtration.

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§ This means the salt which we obtain after having neutralized by barytes the product of the distillation of the aqueous fluid, which was procured from the soap that had been decomposed by tartaric acid.

Saponification of the Elains by Potash.—The determination of the soluble matter which the elaïns yield to water in the process of saponification, is much more difficult than the determination of the same point with respect to the stearins. The stearins are less subject to be changed than the elaïns: it is less difficult to obtain the stearins in a uniformly pure state; besides the saponified fats of the stearins being less fusible than the saponified elaïns; it is more easy to weigh them without loss. The elaïns of the sheep, the hog, the jaguar, and the goose, extracted by alcohol, yield by the action of potash,

Of saponified fat, 89 parts,
Of soluble matter, 11.

The elaïn of the ox extracted in the same manner yields,

Of saponified fat, 92.6 parts,
Of soluble matter, 7.4.

The different kinds of fat, considered in their natural state, are distinguished from each other by their colour, odour, and fluidity.

The stearins of the sheep, the ox, and the hog, have the same degree of solubility in alcohol; the stearin of man is a little more soluble, while that of the goose is twice as much so. The elaïns of man, of the sheep, the ox, the jaguar, and the hog, have a specific gravity of about .915; that of the goose of about .929. The elaïns of the sheep, the ox, and the hog, have the same solubility in alcohol; the elaïn of the goose is a little more soluble. On the other hand, the margaric acids of man, of the hog, of the jaguar, and of the goose, cannot be distinguished from each other; those of the sheep and the ox differ a few degrees in their melting point, and a little also in their form. As for the slight differences which the oleic acids present, they are not sufficiently precise for us to be able to particularize them. See Acid (Oleic).

Fecula. See Starch.

* Fecula. Green of plants. See Chlorophyle.*

* Feldspar. This important mineral genus is distributed by Professor Jameson into four species, viz. prismatic feldspar, pyramidal feldspar, prismato-pyramidal feldspar, and rhomboidal feldspar.

I. Prismatic feldspar has 9 sub-species; 1. Adularia; 2. Glassy feldspar; 3. Ice-spar; 4. Common feldspar; 5. Labrador feldspar; 6. Compact feldspar; 7. Clinkstone; 8. Earthy common feldspar; and, 9. Porcelain earth.

1. *Adularia.* Colour greenish-white; iridescent; and in thin plates, pale flesh-red by transmitted light. Massive and crystallized. Primitive form, an oblique four-sided prism, with 2 broad and 2 narrow lateral planes; the lateral edges are 120° and 60°. Secondary forms; an oblique four-sided prism, a broad rectangular six-sided prism, a six-sided table, and a rectangular four-sided prism. Sometimes twin crystals occur. The lateral planes of the prism are longitudinally streaked. Lustre splendent, intermediate between vitreous and pearly. Cleavage threefold. Fracture imperfect conchoidal. Semi-transparent. A beautiful pearly light is sometimes seen, when the specimen is viewed in the direction of the broader lateral planes. Refracts double. Harder than apatite, but softer than quartz. Easily frangible. Sp. gr. 2.5. It melts before the blow-pipe, without addition, into a white-coloured transparent glass. Its constituents are, 64 silica, 20 alumina, 2 lime, and 14 potash.—*Vauquelin.*

It occurs in contemporaneous veins, or drusy cavities, in granite and gneiss, in the island of Arran, in Norway, Switzerland, France, and Germany. The finest crystals are found in the mountain of Stella, a part of St. Gothard. Rolled pieces, exhibiting a most beautiful pearly light, are collected in the island of Ceylon. Moonstone adularia is found in Greenland; and all the varieties in the United States. Under the name of moonstone it is worked by lapidaries. Another variety from Siberia is called sunstone by the jewellers. It is of a yellowish colour, and numberless golden spots appear distributed through its whole substance. These reflections of light are either from minute fissures, or irregular cleavages of the mineral. The aventurine feldspar of Archangel appears to be also sunstone. It is the hyaloides of Theophrastus.

2. *Glassy feldspar.* Colour grayish-white. Crystallized in broad rectangular four-sided prisms, bevelled on the extremities. Splendent and vitreous. Cleavage threefold. Fracture uneven. Transparent. Sp. gr. 2.57. It melts without addition into a gray semi-transparent glass. Its constituents are, 68 silica, 15 alumina, 14.5 potash, and 0.5 oxide of iron.—*Klapr.* It occurs imbedded in pitch-stone porphyry in Arran and Rum.

3. *Ice spar.* Colour grayish-white. Massive, cellular and porous; and crystallized in small, thin, longish six-sided tables. The lateral planes are longitudi-

nally streaked. Lustre vitreous. Cleavage imperfect. Translucent and transparent. Hard as common feldspar, and easily frangible. It occurs along with nepheline, meionite, mica, and hornblende, at Monte Somma near Naples.

4. *Common feldspar*. Colours white and red, of various shades; rarely green and blue. Massive, disseminated, and crystallized in a very oblique four-sided prism; an acute rhombus; elongated octohedron; a broad equiangular six-sided prism; a rectangular four-sided prism; and twin crystals; which forms are diversified by various bevelments and truncations. Cleavage threefold. Lustre more pearly than vitreous. Fracture uneven. Fragments rhomboidal; and have only four splendent faces. Translucent on the edges. Less hard than quartz. Easily frangible. Sp. gr. 2.57. It is fusible without addition into a gray semi-transparent glass. Its constituents are as follows:

	Siberian green feldspar.	Flesh-red feldspar.	Feldspar from Passau.
Silica,	62 83	66.75	60.25
Alumina,	17.02	17.50	22.00
Lime,	3.00	1.25	0.75
Potash,	13.00	12.00	14.00
Oxide of iron,	1.00	0.75	water, 1.00
	96.85	98.25	98.00
	Vauq.	*Rose.*	*Bucholz.*

Feldspar is one of the most abundant minerals, as it forms a principal constituent part of granite and gneiss, and occurs occasionally mixed with mica-slate and clay-slate. It is also a constituent of whitestone and syenite. It forms the basis of certain porphyries. Greenstone is a compound of common feldspar and hornblende. The most beautiful crystals of it occur in the Alps of Switzerland, in Lombardy, France, and Siberia, in veins of contemporaneous formation with the granite and gneiss rocks. It occurs abundantly in transition mountains, and in those of the secondary class. Under the name of petunze, it is an ingredient of Chinese porcelain. When the green varieties are spotted with white, they are named *aventurine feldspar*. Another green variety from South America is called the Amazon-stone, from the river where it is found.

5. *Labradore feldspar*. Colour gray of various shades. When light falls on it in certain directions, it exhibits a great variety of beautiful colours. It occurs massive, or in rolled pieces. Cleavage splendent. Fracture glistening. Lustre between vitreous and pearly. It breaks into rhomboidal fragments. Translucent in a very low degree. Less easily frangible than common feldspar. Sp. gr. 2.6 to 2.7. It is less fusible than common feldspar. It occurs in rolled masses of syenite, in which it is associated with common hornblende, hyperstene, and magnetic ironstone, in the island of St. Paul on the coast of Labradore. It is found round Laurwig in Norway.

6. *Compact feldspar*. Colours, white, gray, green and red. Massive, disseminated, and crystallized in rectangular four-sided prisms. Lustre glistening, or glimmering. Fracture splintery and even. Translucent only on the edges. Easily frangible. Sp. gr. 2.69. It melts with difficulty into a whitish enamel. Its constituents are, 51 silica, 30.5 alumina, 11.25 lime, 1.75 iron, 4 soda, 1.26 water. —*Klapr.* It occurs in mountain masses, beds and veins: in the Pentland hills, at Sala, Dannemora, and Hallefors in Sweden; in the Saxon Erze-gebirge, and the Hartz.

7. *Clinkstone;* which see.

8. *Earthy common feldspar*. This seems to be disintegrated common feldspar.

9. *Porcelain earth*. See CLAY.

II. *Pyramidal feldspar*. See SCAPOLITE, and ELAOLITE.

III. *Prismato-pyramidal feldspar*. See MEIONITE.

IV. *Rhomboidal feldspar*. See NEPHELINE.

Chiastolite and sodalite have also been annexed to this species by Professor Jameson.*

* FERMENTATION. When aqueous combinations of vegetable or animal matter are exposed to ordinary atmospherical temperatures, they speedily undergo spontaneous changes, to which the generic name of *fermentation* has been given. Animal liquids alone, or mixed with vegetables, speedily become sour. The act which occasions this alteration is called acetous fermentation; because the product is, generally speaking, acetic acid, or vinegar. But when a moderately strong solution of saccharine matter, or saccharine matter and starch, or sweet juices of fruits, suffer this intestine change, the result is an intoxicating liquid, a beer, or wine; whence the process is called vinous fermentation. An ulterior change, to which all moist animal and vegetable matter is liable, accompanied by the disengagement of a vast quantity of fetid gases, is called the putrefactive fermentation.

Each of these processes goes on most rapidly at a somewhat elevated temperature, such as 80° or 100° F. It is for these reasons, that in tropical countries, animal and vegetable substances are so speedily decomposed.

As the ultimate constituents of vegetable matter are oxygen, hydrogen, and carbon; and of animal matter, the same principles with azote, we can readily understand that all the products of fermentation must be merely new compounds of these three or four ultimate constituents. Accordingly, 100 parts of real vinegar, or acetic acid, are resolvable, by MM. Gay-Lussac and Thenard's analysis, into 50.224 carbon + 46.911 hydrogen and oxygen, as they exist in water, + 2.863 oxygen in excess. In like manner, wines are all resolvable into the same ultimate components, in proportions somewhat different. The aeriform results of putrefactive fermentation are in like manner found to be, hydrogen, carbon, oxygen, and azote, variously combined, and associated with minute quantities of sulphur and phosphorus. The residuary matter consists of the same principles, mixed with the saline and earthy parts of animal bodies.

Lavoisier was the first philosopher, who instituted, on right principles, a series of experiments to investigate the phenomena of fermentation, and they were so judiciously contrived, and so accurately conducted, as to give results, comparable to those derived from the more rigid methods of the present day. Since then M. Thenard and M. Gay-Lussac have each contributed most important researches. By the labours of these three illustrious chemists, those material metamorphoses, formerly quite mysterious, seem susceptible of a satisfactory explanation.

1. *Vinous fermentation.* As sugar is a substance of uniform and determinate composition, it has been made choice of for determining the changes which arise when its solution is fermented into wine or alcohol. Lavoisier justly regarded it as a true vegetable oxide, and stated its constituents to be, 8 hydrogen, 28 carbon, and 64 oxygen, in 100 parts. By two different analyses of Berzelius, we have,

Hydrogen,	6.802	6.891
Carbon,	44.115	42.704
Oxygen,	49.083	50.405
	100 000	100.000

MM. Gay-Lussac and Thenard's analysis gives,

Hydrogen,	6.90	57.53 water,
Oxygen,	50.63	
Carbon,	42.47	42.47
	100.00	100.00

It has been said, that sugar requires to be dissolved in at least 4 parts of water, and to be mixed with some yeast, to cause its fermentation to commence. But this is a mistake. Sirup stronger than the above will ferment in warm weather, without addition. If the temperature be low, the sirup weak, and no yeast added, acetous fermentation alone will take place. To determine the vinous, therefore, we must mix certain proportions of saccharine matter, water and yeast, and place them in a proper temperature.

To observe the chemical changes which occur, we must dissolve 4 or 5 parts of pure sugar in 20 parts of water, put the solution into a matrass, and add 1 part of yeast. Into the mouth of the matrass a glass tube must be luted, which is recurved, so as to dip into the mercury of a pneumatic trough. If the apparatus be now placed in a temperature of from 70° to 80°, we shall speedily observe the sirup to become muddy, and a multitude of air bubbles to form all around the ferment. These unite, and attaching themselves to particles of the yeast, rise along with it to the surface, forming a stratum of froth. The yeasty matter will then disengage itself from the air, fall to the bottom of the vessel, to re-acquire buoyancy a second time by attached air bubbles, and thus in succession. If we operate on 3 or 4 ounces of sugar, the fermentation will be very rapid during the first ten or twelve hours; it will then slacken, and terminate in the course of a few days. At this period the matter being deposited, which disturbed the transparency of the liquor, this will become clear.

The following changes have now taken place: 1. The sugar is wholly, and the yeast partially, decomposed. 2. A quantity of alcohol and carbonic acid, together nearly equal in weight to the sugar, is produced. 3. A white matter is formed, composed of hydrogen, oxygen, and carbon, equivalent to about half the weight of the decomposed ferment. The carbonic acid passes over into the pneumatic apparatus; the alcohol may be separated from the vinous liquid by distillation, and the white matter falls down to the bottom of the matrass with the remainder of the yeast.

The quantity of yeast decomposed is very small. 100 parts of sugar require, for complete decomposition, only two and a half of that substance, supposed to be in a dry state. It is hence very probable, that the ferment, which has a strong affinity for oxygen, takes a little of it from the saccharine particles, by a part of its hydrogen and carbon, and thus the equilibrium being broken between the constituent principles of the sugar, these so react on each other, as to be transformed into alcohol and carbonic acid. If we consider the composition of alcohol, we shall find no difficulty in tracing the steps of this transformation. If we take 40 of carbon + 60 of water, or its elements, as the true constituents of sugar, instead of 42.47 + 57.53, and convert these weights into volumes, we shall have for the composition of that body, very nearly, *by weight*,

1st, 1 volume vapour of carbon, = 0.416
1 volume vapour of water, = 0.625
or, 1 volume vapour of carbon,
1 ditto hydrogen gas,
½ ditto oxygen;
or, multiplying each by 3,
3 volumes vapour of carbon,
3 ditto hydrogen,
$\frac{3}{2}$ ditto oxygen.

2d, Let us bear in mind that alcohol is composed of

$$\text{1 vol. olefiant gas} = \left\{\begin{array}{l}\text{2 vols. vap. of carb.}\\ \text{2 vols. hydrogen.}\end{array}\right.$$

$$\text{1 do. vap. of water} = \left\{\begin{array}{l}\text{1 vol. hydrogen,}\\ \text{½ vol. oxygen.}\end{array}\right.$$

3d, 1 vol. carbonic acid = 1 vol. oxygen + 1 vol. vapour of carbon.

4. Neglecting the minute products which the yeast furnishes, in the act of fermentation, let us regard only the alcohol and carbonic acid. We shall then see, on comparing the composition of sugar to that of alcohol, that to transform sugar into alcohol, we must withdraw from it one volume of vapour of carbon, and one volume of oxygen, which form by their union one volume of carbonic acid gas. Finally, let us reduce the volumes into weights, we shall find, that 100 parts of sugar ought to be converted, during fermentation, into 51.55 of alcohol, and 48.45 of carbonic acid.

Those who are partial to atomical language will see that sugar may be represented by

	Atoms.		
3 vol. vap. of carbon,	= 3 =	2.250	40.00
3 do. hydrogen, -	= 3 =	0.375	6.66
$\frac{3}{2}$ do. oxygen -	= 3 =	3.000	53.33
		5.625	99.99
And alcohol, by			
2 vol. carbon, -	= 2 =	1.500	52.16
3 do. hydrogen, -	= 3 =	0.375	13.04
½ do. oxygen, -	= 1 =	1.000	34.80
		2.875	100.00
And carbonic acid, by			
1 vol. oxygen, -	= 2 =	2.00	72.72
1 do. vap. of carbon,	= 1 =	0.75	27.28
			100.00

If, therefore, from the sugar group, we take away one atom of carbon, and two of oxygen, to form the carbonic acid group below, we leave an atomic assemblage for formng alcohol, as in the middle. For this interesting developement of the relation between the ultimate constituents of sugar on the one hand, and alcohol and carbonic acid on the other, we are indebted to M. Gay-Lussac.

The following beautiful comparison, by the same philosopher, illustrates these metamorphoses:

Sulphuric ether is composed of

Dens. of vapour.

$$\left.\begin{array}{l}\text{2 vol. olefiant gas} = 1.9444\\ \text{1 do. vap. of water} = 0.6250\end{array}\right\}\ 2.5694.$$

And alcohol is composed of

$$\left.\begin{array}{l}\text{2 vol. olefiant gas} = 1.9444\\ \text{2 do. vap. of water} = 1.2500\end{array}\right\} \div 2 = 1.5972.$$

Hence to convert alcohol into ether, we have only to withdraw from it one-half of its constituent water.

Let us now see how far experiment agrees with the theoretic deduction, that 100 parts of sugar, by fermentation, should give birth to 51.55 of absolute alcohol, and 48.45 of carbonic acid. In Lavoisier's elaborate experiment, we find, that 100 parts of sugar afforded,

Alcohol,	57.70
Carbonic acid,	35.34
	93.04

Unfortunately, this great chemist has omitted to state the specific gravity of his alcohol.

If we assume it to have been 0.8293, as assigned for the density of *highly* rectified alcohol in the 8th table of the appendix to his *Elements*, we shall find 100 parts of it to contain, by Lowitz's table, 87.23 of absolute alcohol, if its temperature had been 60°. But as 54.5° was the thermometric point indicated in taking sp. gravities, we must reduce the density from 0.8293 to 0.827. We shall then find 100 parts of it, to consist of 88 of absolute alcohol, and 12 of water. Hence, the 57.7 parts obtained by Lavoisier will become 50.776 of absolute alcohol, which is a surprising accordance with the theoretical quantity 51.55. But about four parts of the sugar, or 1-25th, had not been decomposed. If we add two parts of alcohol for this, we would have a small deviation from theory on the other side. There is no reasonable ground for questioning the accuracy of Lavoisier's experiments on fermentation. Any person who considers the excessive care he has evidently bestowed on them, the finished precision of his apparatus, and the complacency with which he compares "the substances submitted to fermentation, and the products resulting from that operation, as forming an algebraic equation," must be convinced that the results are deserving of confidence. Unlike the crude and contradictory researches, which modern vanity blazons in our Journals, those of Lavoisier on fermentation, like the coeval inquiries of Cavendish on air, will never become obsolete.

M. Thenard, in operating on a solution of 300 parts of sugar, mixed with 60 of yeast, at the temperature of 59°, has obtained such results as abundantly confirm the previous determination of Lavoisier. The following were the products:

Alcohol of 0.822,	171.5
Carbonic acid,	94.6
Nauseous residue,	12.0
Residual yeast,	40.0
	318.1
Loss,	41.9
	360.0

The latter two ingredients may be disregarded in the calculation, as the weight of the yeast is nearly equivalent to their sum.

Dividing 171.5 by 3, we have 57.17 for the weight of alcohol of 0.822 from 100 of sugar. In the same way we get 31.53 for the carbonic acid. Now, spirit of wine of 0.822 contains 90 per cent of absolute alcohol. Whence, we find 51.453 for the quantity of absolute alcohol by Thenard's experiment; being a perfect accordance with the theoretical deductions of M. Gay-Lussac, made at a *subsequent* period.

By M. Lavoisier.	*By M. Thenard.*	*By Theory.*
From 100 sugar.	From 100 do.	
Abs. alco. 50.776	51.453	51.55

The coincidence of these three results seems perfectly decisive.

In determining the density of absolute alcohol, M. Gay-Lussac had occasion to observe, that when alcohol is mixed with water, the density of the vapour is exactly the mean between the density of the alcoholic vapour, and that of the aqueous vapour, notwithstanding the affinity which tends to unite them. An important inference flows from this observation. The experiments of M. de Saussure, as corrected by M. Gay-Lussac's theory of volumes, demonstrate, that the absolute alcohol which they employed contains no separable portion of water, but what is essential to the existence of the liquid alcohol. Had any foreign water been present, then the specific gravity of the alcoholic vapour would have been proportionally diminished; for the vapour of water is less dense than that of alcohol, in the ratio of 1 to more than 2½. But since the sp. gravity of alcoholic vapour is precisely that which would result from the condensed union of one volume vapour of carbon, one volume of hydrogen, and half a volume of oxygen, it seems absurd to talk of such alcohol still containing 8.3 per cent of water.

The writer of a long article on *brewing*, in the supplement to the 5th edition of the Encyclopædia Britannica, makes the following remarks in discussing M. Thenard's researches on fermentation. "Now, alcohol of the specific gravity 0.822 contains one-tenth of its weight of water, which can be separated from it; and if we suppose with Saussure, that absolute alcohol contains 8.3 *per cent* of water, then the products of sugar decomposed by fermentation, according to Saussure's (Thenard's he means) experiments, are as follows:

Alcohol,	47.7
Carbonic acid,	35.34
	83.04
Or in 100 parts,	
Alcohol,	57.44
Carbonic acid,	42.56
	100.00

"This result approaches so nearly to that of Lavoisier, that there is reason to suspect that the coincidence is more than accidental." p. 480.

This insinuation against the integrity of one of the first chemists in France, calls for reprehension. But farther, M. Gay-Lussac's account of the nature of alcohol and its vapour was published a considerable time before the article *brewing* appeared. Indeed our author copies a considerable part of it, so that the above error is less excusable.

The ferment or yeast is a substance which separates under the form of flocculi, more or less viscid, from all the juices and infusions which experience the vinous fermentation. It is commonly procured from the beer manufactories, and is hence called the barm of beer. It may be easily dried, and is actually exposed for sale in Paris under the form of a firm but slightly cohesive paste, of a grayish-white colour. This pasty barm, left to itself in a close vessel, at a temperature of from 55° to 70°, is decomposed, and undergoes in some days the putrid fermentation. Placed in contact, at that temperature, with oxygen in a jar inverted over mercury, it absorbs this gas in some hours, and there is produced carbonic acid and a little water. Exposed to a gentle heat, it loses more than two-thirds of its weight, becomes dry, hard, and brittle, and may in this state be preserved for an indefinite time. When it is more highly heated, it experiences a complete decomposition, and furnishes all the products which usually result from the distillation of animal substances.

It is insoluble in water and alcohol. Boiling water speedily deprives it of its power of readily exciting fermentation.—In fact, if we plunge the solid yeast into water for ten or twelve minutes, and place it afterwards in contact with a saccharine solution, this exhibits no symptom of fermentation for a long period. By that heat, the ferment does not seem to lose any of its constituents, or to acquire others. Its habitudes with acids and alkalis have not been well investigated. From Thenard's researches, the fermenting principle in yeast seems to be of a caseous or glutinous nature.

It is to the gluten that wheat flour owes its property of making a fermentable dough with water. This flour paste may indeed be regarded as merely a viscid and elastic tissue of gluten, the interstices of which are filled with starch, albumen, and sugar. We know that it is from the gluten, that the dough derives its property of rising on the admixture of leaven. The leaven acting on the sweet principle of the wheat, gives rise in succession to the vinous and acetous fermentations, and of consequence to alcohol, acetic and carbonic acids. The latter gas tends to fly off, but the gluten resists its disengagement, expands like a membrane, forms a multitude of little cavities, which give lightness and sponginess to the bread. For the want of gluten, the flour of all those grains and roots which consist chiefly of starch are not capable of making raised bread, even with the addition of leaven or yeast. There does not appear to be any peculiar fermentation to which the name *panary* should be given.*

When it is required to preserve fermented liquors in the state produced by the first stage of fermentation, it is usual to put them into casks before the vinous process is completely ended; and in these closed vessels a change very slowly continues to be made for many months, and perhaps for some years.

But if the fermentative process be suffered to proceed in open vessels, more especially if the temperature be raised to 90 degrees, the acetous fermentation comes on. In this, the oxygen of the atmosphere is absorbed; and the more speedily in proportion as the surfaces of the liquor are often changed by lading it from one vessel to another. The usual method consists in exposing the fermented liquor to the air in open casks, the bunghole of which is covered with a tile to prevent the entrance of the rain. By the absorption of oxygen which takes place, the inflammable spirit becomes converted into an acid. If the liquid be then exposed to distillation, pure vinegar comes over instead of ardent spirit.

When the spontaneous decomposition is suffered to proceed beyond the acetous process, the vinegar becomes viscid and foul; air is emitted with an offensive smell; volatile alkali flies off; an earthy sediment is deposited; and the remaining liquid, if any, is mere water. This is the putrefactive process.

The fermentation by which certain colouring matters are separated from vegetables, as in the preparation of woad and indigo, is carried much farther, approaching the putrefactive stage.

It is not clearly ascertained what the yeast or ferment performs in this operation. It seems probable, that the fermentative process in considerable masses would be carried on progressively from the surface downwards; and would perhaps, be completed in one part before it had perfectly commenced in another, if the yeast, which is already in a state of fermentation, did not cause the process to begin in every part at once. See BREAD, DISTILLATION, PUTREFACTION, ALCOHOL, WINE, ACID (ACETIC), VEGETABLE KINGDOM.

* FERROCYANATES. SEE ACID (FERROPRUSSIC).*

* FERROCYANIC ACID. See ACID (FERROPRUSSIC).*

* FERROPRUSSIC ACID, and FERROPRUSSIATES. See ACID (FERROPRUSSIC).*

* FERRURETTED CHYAZIC ACID. The same as Ferroprussic.*

* FETSTEIN. Elaolite.*

* FIBRIN. A peculiar organic compound found both in vegetables and animals. Vauquelin discovered it in the juice of the papaw tree. It is a soft solid, of a greasy appearance, insoluble in water, which softens in the air, becoming viscid, brown, and semi-transparent. On hot coals it melts, throws out greasy drops, crackles, and evolves the smoke and odour of roasting meat. Fibrin is procured, however, in its most characteristic state from animal matter. It exists in chyle; it enters into the composition of blood. Of it, the chief part of muscular flesh is formed; and hence it may be regarded as the most abundant constituent of the soft solids of animals.

To obtain it, we may beat blood, as it issues from the veins, with a bundle of twigs. Fibrin soon attaches itself to each stem, under the form of long reddish filaments, which become colourless by washing them with cold water. It is solid, white, insipid, without smell, denser than water, and incapable of effecting the hue of litmus or violets. When moist it possesses a species of elasticity; by desiccation it becomes yellowish, hard, and brittle. By distillation we can extract from it much carbonate of ammonia, some acetate, a fetid brown oil, and gaseous products; while there remains in the retort a very voluminous charcoal, very brilliant, difficult of incineration, which leaves after combustion, phosphate of lime, a little phosphate of magnesia, carbonate of lime, and carbonate of soda.

Cold water has no action on fibrin. Treated with boiling water, it is so changed as to lose the property of softening and dissolving in acetic acid. The liquor filtered from it, yields precipitates with infusion of galls, and the residue is white, dry, hard, and of an agreeable taste.

When kept for some time in alcohol of 0.810, it gives rise to an adipocerous matter, having a strong and disagreeable odour. This matter remains dissolved in the alcohol, and may be precipitated by water. Ether makes it undergo a similar alteration, but more slowly. When digested in weak muriatic acid, it evolves a little azote, and a compound is formed, hard, horny, and which washed repeatedly with water, is transformed into another gelatinous compound. This seems to be a neutral muriate, soluble in hot water; whilst the first is an acid muriate, insoluble even in boiling water. Sulphuric acid, diluted with six times its weight of water, has similar effects. When not too concentrated, nitric acid has a very different action on fibrin. For example, when its sp. gr. is 1.25, there results from it at first a disengagement of azote, while the fibrin becomes covered with fat, and the liquid turns yellow. By digestion of 24 hours, the whole fibrin is attacked, and converted into a pulverulent mass of a lemon-yellow colour, which seems to be composed of a mixture of fat and fibrin, altered and intimately combined with the malic and nitric or nitrous acids. In fact, if we put this mass on a filter, and wash it copiously with water, it will part with a portion of its acid, will preserve the property of reddening litmus, and will take an orange hue. On treating it afterwards with boiling alcohol, we dissolve the fatty matter; and putting the remainder in contact with chalk and water, an efflorescence will be occasioned by the escape of carbonic acid, and malate or nitrate of lime will remain in solution.

Concentrated acetic acid renders fibrin soft at ordinary temperatures, and converts it by the aid of heat into a jelly, which is soluble in hot water, with the disengagement of a small quantity of azote. This solution is colourless, and possesses little taste. Evaporated to dryness, it leaves a transparent residue, which reddens litmus paper, and which cannot be dissolved even in boiling water, but by the medium of more acetic acid Sulphuric, nitric, and muriatic acids, precipitate the animal matter, and form acid combinations. Potash, soda, ammonia, effect likewise the precipitation of this matter, provided we do not use too great an excess of alkali; for then the precipitated matter would be redissolved. Aqueous potash and soda gradually dissolve fibrin in the cold, without occasioning any perceptible change in its nature; but with heat they decompose it, giving birth to a quantity of ammoniacal gas, and other usual animal products. Fibrin does not putrefy speedily when kept in water. It shrinks on exposure to a considerable heat, and emits the smell of burning horn. It is composed, according to the analysis of MM. Gay-Lussac and Thenard, of Carbon, 53.360
Azote, 19.934
Oxygen, 19.685 } 22.14 water
Hydrogen, 7.021 } 4.56 hydrogen.*

* **Fibrolite.** Colours white and gray; crystallized in rhomboidal prisms, the angles of whose planes are 80° and 100°. It is glistening internally. Principal fracture uneven. Harder than quartz. Sp. gr. 3.214. Its constituents are alumina 58.25, silica 38, iron and loss 3.75. It is found in the Carnatic.—*Jameson.**

* **Figurestone.** See **Bildstein.***

Filtration. An operation, by means of which a fluid is mechanically separated from consistent particles merely mixed with it. It does not differ from straining.

An apparatus fitted up for this purpose is called a filter. The form of this is various, according to the intention of the operator. A piece of tow, or wool, or cotton, stuffed into the pipe of a funnel, will prevent the passage of grosser particles, and by that means render the fluid clearer which comes through. Sponge is still more effectual. A strip of linen rag wetted and hung over the side of a vessel containing a fluid, in such a manner as that one end of the rag may be immersed in the fluid, and the other end may remain without, below the surface, will act as a syphon, and carry over the clearer portion. Linen or woollen stuffs may either be fastened over the mouths of proper vessels, or fixed to a frame, like a sieve, for the purpose of filtering. All these are more commonly used by cooks and apothecaries than by philosophical chemists, who, for the most part, use the paper called cap-paper, made up without size.

As the filtration of considerable quantities of fluid could not be effected at once without breaking the filter of paper, it is found requisite to use a linen cloth, upon which the paper is applied and supported.

Precipitates and other pulverulent matters are collected more speedily by filtration than by subsidence. But there are many chemists who disclaim the use of this method, and avail themselves of the latter only, which is certainly more accurate, and liable to no objection, where the powders are such as will admit of edulcoration and drying in the open air.

Some fluids, as turbid water, may be purified by filtering through sand. A large earthen funnel, or stone bottle with the bottom beaten out, may have its neck loosely stopped with small stones, over which smaller may be placed, supporting layers of gravel increasing in fineness, and lastly covered to the depth of a few inches with fine sand, all thoroughly cleansed by washing. This apparatus is superior to a filtering stone, as it will cleanse water in large quantities, and may readily be renewed when the passage is obstructed, by taking out and washing the upper stratum of sand.

A filter for corrosive liquors may be constructed, on the same principles, of broken and pounded glass.

Fire. See Caloric and Combustion.

* **Fire-damp.** See Combustion and Carburetted Hydrogen.*

* **Fish-scales** are composed of alternate layers of membrane and phosphate of lime.*

* **Fixed Air.** Carbonic acid gas.*

Fixity. The property by which bodies resist the action of heat, so as not to rise in vapour.

* **Flake-white.** Oxide of bismuth.*

Flame. See Combustion.

* **Flesh.** The muscles of animals. They consist chiefly of fibrin, with albumen, gelatin, extractive, phosphate of soda, phosphate of ammonia, phosphate and carbonate of lime, and sulphate of potash. See Muscle.*

* **Flint.** Colour generally gray, with occasionally zoned and striped delineations. Massive, in rolled pieces, tuberose and perforated. It rarely occurs in supposititious, hollow, pyramidal or prismatic crystals. It occurs often in extraneous shapes, as echinites, coralites, madreporites, fungites, belemnites, mytilites, &c.; sometimes in lamellar concretions. Internal lustre glimmering. Fracture conchoidal. Fragments sharp-edged. Translucent. Harder than quartz. Easily frangible. Sp. gr. 2.59. Infusible without addition, but whitens and becomes opaque. Its constituents are 98 silica, 0.50 lime, 0.25 alumina, 0.25 oxide of iron, 1.0 loss. When two pieces of flint are rubbed together in the dark, they phosphoresce, and emit a peculiar smell.

It occurs in primitive, transition, secondary, and alluvial mountains. In the first two, in metalliferous and agate veins. In secondary countries it is found in puddingstone, limestone, chalk, and amygdaloid. In chalk it occurs in great abundance in beds. These seem to have been both formed at the same time. Werner, however, is of opinion, that the tuberose and many other forms, have been produced by infiltration. In Scotland, it occurs imbedded in secondary limestone in the island of Mull, and near Kirkaldy in Fifeshire. In England, it abounds in alluvial districts in the form of gravel, or is imbedded in chalk. In Ireland it occurs in considerable quantities in secondary limestone. It is found in most parts of the world. Its principal use is for gun flints, the mechanical operations of which manufacture, are fully detailed by Brongniart. The best flint for this purpose, is the yellowish-gray. It is an ingredient in pottery, and chemists use it for mortars.*

* **Flinty-slate.** Of this mineral there are two kinds, common flinty-slate, and Lydian stone.

1. *Common.* Colour ash-gray, with other colours, in flamed, striped, and spotted delineations. It is often traversed by quartz veins. Massive, and in lamellar concretions. Internally it is faintly glimmering. Fracture in the great slaty, in the small splintery. Translucent. Hard. Uncommonly difficultly frangible. Sp. gr. 2.63. It occurs in beds, in clay-slate and gray-wacke; and in roundish and angular masses in sandstone. It is found in different parts of the great tract of clay-slate and gray-wacke which extends from St. Abb's-head to Portpatrick; also in the Pentland hills near Edinburgh.

2. *Lydian stone.* Colour grayish-black, which passes into velvet-black. It occurs massive, and rolled in pieces with glistening surfaces. Internally it is glimmering. Fracture even. Opaque. Less hard than flint. Difficultly frangible. Sp. gr. 2.6. It occurs very frequently along with common flinty-slate in beds in clay-slate. It is found near Prague and Carlsbad in Bohemia, in Saxony, the Hartz, and at the Moorfoot and Pentland hills near Edinburgh. It is sometimes used as a touchstone for ascertaining the purity of gold and silver. See Assay.*

* **Floatstone.** A sub-species of the indivisible quartz of Mohs. Spongiform quartz of Jameson. Colour white of various shades. In porous, massive, and tuberose forms. Internally it is dull. Fracture coarse earthy. Feebly translucent on the edges. Soft, but its minute particles are as hard as quartz. Rather brittle. Easily frangible. Feels meagre and rough, and emits a grating noise, when the finger is drawn across it. Sp. gr. 0.49. Its constituents are silica 98, carbonate of lime 2.—*Vauq.* It occurs encrusting flint, or in imbedded masses in a secondary limestone at St. Ouen near Paris.—*Jameson.**

Flour. The powder of the gramineous seeds. Its use as food is well known. See Bread.

Flowers. A general appellation used by the elder chemists, to denote all such bodies as have received a pulverulent form by sublimation.

Flowers of Vegetables. Dr. Lewis in his notes on Neumann's Chemistry, gives a cursory account of many experiments, made with a view to ascertain how far the colour of vegetable flowers might prove of use to the dyer. He found very few capable of being applied to valuable purposes.

* **Fluates.** Compounds of the salifiable bases with fluoric acid.*

Fluidity. The state of bodies when their parts are very readily moveable in all directions with respect to each other. See Caloric.

* **Fluoborates.** Compounds of fluoboric acid with the salifiable bases.*

* **Fluor.** Octohedral fluor of Jameson. It is divided into three sub-species; compact fluor, foliated fluor, and earthy fluor.

1. *Compact.* Colours, greenish-gray and greenish-white. Massive. Dull or feebly glimmering. Fracture even. Fragments sharp-edged. Translucent. Harder than calcareous spar, but not so hard as apatite. Brittle, and easily frangible. Sp. gr. 3.17. It is found in veins, associated with fluor spar, at Stolberg in the Hartz.

2. *Foliated.* Colours, white, yellow, green, and blue. Green cubes appear with white angles. Massive, disseminated, and in distinct concretions. Crystallized in cubes, perfect or variously truncated and bevelled; in the rhomboidal dodecahedron, and the octohedron, or double four-sided pyramid. The crystals are generally placed on one another, and form druses; but are seldom single. Surface smooth and splendent, or drusy and rough. Internal lustre, specular-splendent, or shining vitreous. Cleavage, fourfold equiangular, parallel with the planes of an octohedron. Fragments octohedral or tetrahedral. Translucent to transparent. Single refraction. Harder than calcareous spar, but not so hard as apatite. Brittle, and easily frangible. Sp. gr. 3.15. Before the blow-pipe it generally decrepitates, gradually loses its colour and transparency, and melts without addition into a grayish-white glass. When two fragments are rubbed together, they become luminous in the dark. When gently heated, it phosphoresces with a blue and green light. By ignition it loses its phosphorescent property. The violet blue variety from Nertschinsky, called *chlorophane*, when placed on glowing coals, does not decrepitate, but soon throws out a green light. Sulphuric acid evolves from pulverized fluor spar, acid fumes which corrode glass. Its constituents, by Berzelius, are 72.1 lime, and 27.9 fluoric acid. It occurs principally in veins that traverse primitive, transition, and sometimes secondary rocks. It has been found only in four places in Scotland, near Monaltree in Aberdeenshire, in gneiss in Sunderland, in secondary porphyry near Gourock in Renfrewshire, and in the island of Papastour, one of the Shetlands. It occurs much more abundantly in England, being found in all the galena veins that traverse the coal formation in Cumberland and Durham; in secondary or floetz limestone in Derbyshire; and it is the most common veinstone in the copper, tin, and lead veins, that traverse granite clay-slate, &c. in Cornwall and Devonshire. It is also frequent on the Continent of Europe. It is cut into ornamental forms. It has also been used as a flux for ores; whence its name *fluor.—Jameson.*

3. *Earthy fluor.* Colour, grayish-white and violet-blue, sometimes very deep. It occurs generally in crusts investing some other mineral. Dull. Earthy. Friable. Its constituents are the same as the preceding. It occurs in veins along with fluor spar at Beeralstone in Devonshire; in Cumberland, in Saxony, and Norway.*

* **Fluoric Acid.** See **Acid (Fluoric.)***

* **Fluorine.** The imaginary radical of the above acid.*

* **Fluosilicates.** See **Acid (Fluosilicic).***

Flux. A general term made use of to denote any substance or mixture added to assist the fusion of minerals. In the large way, limestone and fusible spar are used as fluxes. The fluxes made use of in assays, or philosophical experiments, consist usually of alkalis, which render the earthy mixtures fusible, by converting them into glass; or else glass itself in powder.

Alkaline fluxes are either the crude flux, the white flux, or the black flux. Crude flux is a mixture of nitre and tartar, which is put into the crucible with the mineral intended to be fused. The detonation of the nitre with the inflammable matter of the tartar, is of service in some operations; though generally it is attended with inconvenience on account of the swelling of the materials, which may throw them out of the vessel, if proper care be not taken either to throw in only a little of the mixture at a time, or to provide a large vessel.

White flux is formed by projecting a mixture of equal parts of nitre and tartar, by moderate portions at a time, into an ignited crucible. In the detonation which ensues, the nitric acid is decomposed and flies off with the tartaric acid, and the remainder consists of the potash in a state of considerable purity. This has been called fixed nitre.

Black flux differs from the preceding, in the proportion of its ingredients. In this the weight of the tartar is double that of the nitre; on which account the combustion is incomplete, and a considerable portion of the tartaric acid is decomposed by the mere heat, and leaves a quantity of coal behind, on which the black colour depends. It is used where metallic ores are intended to be reduced, and effects this purpose, by combining with the oxygen of the oxide.

The advantage of M. Morveau's reducing flux, seems to depend on its containing no excess of alkali. It is made of eight parts of pulverized glass, one of calcined borax, and half a part of powder of charcoal. Care must be taken to use a glass which contains no lead. The white glasses contain in general a large proportion, and the green bottle glasses are not perhaps entirely free from it.

Forge Furnace. The forge furnace

consists of a hearth, upon which a fire may be made, and urged by the action of a large pair of double bellows, the nozzle of which is inserted through a wall or parapet constructed for that purpose.

Black-lead pots, or small furnaces of every desired form, may be placed, as occasions require, upon the hearth; and the tube of the bellows being inserted into a hole in the bottom of the furnace, it becomes easy to urge the heat to almost any degree required.

* **Formations.** See Geology.*

* **Formiates.** Compounds of formic acid with the salifiable bases.*

* **Freezing.** See Caloric, and Congelation.*

* **Fossil Copal,** or Highgate resin. Its colour is pale muddy yellowish-brown. It occurs in irregular roundish pieces. Lustre resinous. Semi-transparent. Brittle. Yields easily to the knife. Sp. gr. 1.046. When heated, it gives out a resinous aromatic odour, melts into a limpid fluid, takes fire at a lighted candle, and burns entirely away before the blow-pipe. Insoluble in potash ley. Found in the bed of blue clay at Highgate near London. *Aikin's Mineralogy.**

Frankincense. See Olibanum.

French Berries. The fruit of the *Rhamnus infectorius*, called by the French *graines d'Avignon.* They give a pretty good yellow colour, but void of permanency. When used for dyeing, the cloth is prepared in the same manner as for weld.

Friesland Green. Ammoniaco-muriate of copper, the same with Brunswick green. See Copper.

Fritt. The materials of glass are first mixed together, and then exposed to calcination by a degree of heat not sufficient to melt them. The mass is then called fritt.

Fruits of Vegetables. Sap Green is prepared from the berries of buckthorn, and Annotto is obtained from the pellicles of the seeds of an American tree. See the words.

Fuliginous. Vapours which possess the property of smoke; namely, opacity, and the disposition to apply themselves to surrounding bodies in the form of a dark coloured powder.

* **Fullers' Earth.** Colour greenish-white, and other shades of green. Massive. Dull. Fracture uneven. Opaque. Shining and resinous in the streak. Very soft. Sectile. Scarcely adheres to the tongue. Feels greasy. Sp. gr. 1.7 to 2.2. It falls into a powder with water, without the crackling noise which accompanies the disintegration of bole. It melts into a brown spongy scoria before the blow-pipe. Its constituents are 53 silica, 10 alumina, 1.25 magnesia, 0.50 lime, 0.10 muriate of soda, trace of potash, oxide of iron 9.75, water 24.—*Klaproth.* Bergmann found 24 alumina, and only 0.7 oxide of iron. In England it occurs in beds, sometimes above, sometimes below, the chalk formation; at Rosswein in Upper Saxony, under strata of greenstone slate; and in different places in Germany it is found immediately under the soil. The best is found in Buckinghamshire and Surry. When good, it has a greenish-white, or greenish-gray colour, falls into powder in water, appears to melt on the tongue like butter, communicates a milky hue to water, and deposites very little sand when mixed with boiling water. The remarkable detersive property on woollen cloth, depends on the alumina, which should be at least one-fifth of the whole, but not much more than one-fourth, lest it become too tenacious.—*Jameson.**

Fulminating and Fulmination. In a variety of chemical combinations, it happens, that one or more of the principles assume the elastic state with such rapidity, that the stroke against the displaced air produces a loud noise. This is called fulmination, or much more commonly detonation.

Fulminating gold, and fulminating powder, are the most common substances of this kind, except gunpowder. For the latter of these, see the article Gunpowder. The fulminating powder is made by triturating in a warm mortar, three parts by weight of nitre, two of carbonate of potash, and one of flowers of sulphur. Its effects, when fused in a ladle, and then set on fire, are very great. The whole of the melted fluid explodes with an intolerable noise, and the ladle is commonly disfigured, as if it had received a strong blow downwards.

If a solution of gold be precipitated by ammonia, the product will be fulminating gold. Less than a grain of this, held over the flame of a candle, explodes with a very sharp and loud noise. This precipitate, separated by filtration, and washed, must be dried without heat, as it is liable to explode with no great increase of temperature; and it must not be put into a bottle, closed with a glass stopple, as the friction of this would expose the operator to the same danger.

Fulminating silver may be made by precipitating a solution of nitrate of silver by lime-water, drying the precipitate by exposure to the air for two or three days, and pouring on it liquid ammonia. When it is thus converted into a black powder, the liquid must be poured off, and the powder left to dry in the air. It detonates with the gentlest heat, or even with the slightest friction, so that it must not be removed from the vessel in which it is made. If a drop of water fall upon it, the percussion will cause it to explode. It was discovered by Berthollet.

Brugnatelli made a fulminating silver by powdering a hundred grains of nitrate of silver, putting the powder into a beer glass, and pouring on it, first an ounce of alcohol, then as much concentrated nitrous acid. The mixture grows hot, boils, and an ether is visibly formed, that changes into gas. By degrees the liquor becomes milky and opaque, and is filled with small white clouds. When all the gray powder has taken this form, and the liquor has acquired a consistency, distilled water must be added immediately to suspend the ebullition, and prevent the matter from being redissolved, and becoming a mere solution of silver. The white precipitate is then to be collected on a filter, and dried. The force of this powder greatly exceeds that of fulminating mercury. It detonates in a tremendous manner, on being scarcely touched with a glass tube, the extremity of which has been dipped in concentrated sulphuric acid. A single grain, placed on a lighted coal, makes a deafening report. The same thing happens, if it be placed on a bit of paper on an electric pile, and a spark drawn from it.

Fulminating mercury was discovered by Mr. Howard. A hundred grains are to be dissolved with heat in an ounce and half by measure of nitric acid. The solution, when cold, is to be poured on two ounce measures of alcohol, and heat applied till an effervescence is excited. As soon as the precipitate is thrown down, it must be collected on a filter, that the acid may not react on it; washed, and dried by a very gentle heat. It detonates with a very little heat or friction.

Three parts of chlorate of potash, and one of sulphur, triturated in a metal mortar, cause numerous successive detonations, like the cracks of a whip, the reports of a pistol, or the fire of musketry, according to the rapidity and force of the pressure employed. A few grains, struck with a hammer on an anvil, explode with a noise like that of a musket, and torrents of purple light appear round it. Thrown into concentrated sulphuric acid, it takes fire, and burns with a white flame, but without noise.

Six parts of the chlorate, one of sulphur, and one of charcoal, detonate by the same means, but more strongly, and with a redder flame.

Sugar, gum, or charcoal mixed with the chlorate, and fixed or volatile oils, alcohol, or ether, made into a paste with it, detonate very strongly by the stroke, but not by trituration. Some of them take fire, but slowly and by degrees, in the sulphuric acid.

All these mixtures, that detonate by the stroke, explode much more loudly if previously wrapped up in double paper.

* Fulminations of the most violent kind require the agency of azote or nitrogen; as we see not only in its compounds with the oxides of gold, silver, and platina; but still more remarkably in its chloride and iodide. See NITROGEN.*

FUMING LIQUOR. The fuming liquors of Boyle and Libavius have been long known. To prepare that of Boyle, which is a hydroguretted sulphuret of ammonia, three parts of lime fallen to powder in the air, one of muriate of ammonia, and one of flowers of sulphur, are to be mixed in a mortar, and distilled with a gentle heat. The yellow liquor, that first comes over, emits fetid fumes. It is followed by a deeper coloured fluid, that is not fuming.

The fuming liquor of Libavius is made by amalgamating tin with half its weight of mercury, triturating this amalgam with an equal weight of corrosive muriate of mercury, and distilling by a gentle heat. A colourless fluid at first passes over: after this, a thick vapour is thrown out at one single jet with a sort of explosion, which condenses into a transparent liquor, that emits copious, white, heavy, acrid fumes on exposure to the air. In a closely stopped bottle, no fumes from it are perceptible; but needle-shaped crystals form against the top of the bottle, so as frequently to close the aperture.

Cadet's fuming liquor is prepared by distilling equal parts of acetate of potash and arsenious acid, and receiving the product into glass bottles, kept cool by a mixture of ice and salt. The liquor produced, emits a very dense, heavy, fetid noxious vapour, and inflames spontaneously in the open air.

* FUNGATES. The saline compounds of a peculiar acid, which M. Braconnot has lately extracted from mushrooms.*

* FUNGIN. The fleshy part of mushrooms, deprived by alcohol and water of every thing soluble. It seems to be a modification of woody fibre.*

FURNACE. See LABORATORY.

FUSIBILITY. That property by which bodies assume the fluid state.

Some chemists have asserted that fusion is simply a solution in caloric; but this opinion includes too many yet undecided questions, to be hastily adopted.

FUSION. The act of fusing. Also the state of a fused body.

FUSTET. The wood of the *rhus cotinus*, or Venus's sumach, yields, a fine orange colour, but not at all durable.

FUSTIC, or YELLOW WOOD. This wood, the *morus tinctoria*, is a native of the West Indies. It affords much yellow colouring matter, which is very permanent.

The yellow given by fustic without any

mordant is dull, and brownish, but stands well. The mordants employed with weld act on it in a similar manner, and by their means the colour is rendered more bright and fixed. The difference between them is, that the yellow of fustic inclines more to orange than that of weld; and, as it abounds more in colouring matter, a less quantity will suffice.

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***GABBRONIT.** Scapolite.*

* **Gadolinite.** Prismatic gadolinite.—*Mohs.*

Its colours are velvet-black, and black of various shades. Massive and disseminated. Rarely crystallized. Its primitive figure seems to be an oblique four-sided prism, in which the obtuse angle is nearly 110°. This prism sometimes occurs with six lateral planes. Lustre resinous inclining to vitreous. Fracture conchoidal. Very faintly translucent on the thinnest edges, and then it appears blackish-green. Harder than feldspar, but softer than quartz. Streak greenish-gray. Brittle; difficultly frangible. When pure it does not affect the magnet. Sp. gr. 4.0 to 4.2. It intumesces very much before the blow-pipe, and at length melts into an imperfect slag, which is magnetical. It loses its colour in nitric acid, and gelatinizes. Its constituents are 25.8 silica, 45 yttria, 16.69 oxide of cerium, 10.26 oxide of iron, 0.60 volatile matter.—*Berzelius.* It occurs along with yttrotantalite at Ytterby in Sweden, in beds of a coarse granular red feldspar, which are situated in mica slate; at Finbo, near Fahlun also in Sweden, in a coarse granular granite, along with pyrophysalite and tin-stone.—*Jameson.**

* **Gahnite.** Automalite or octohedral corundum.*

* **Gallitzinite.** Rutile. An ore of titanium.*

Galbanum exudes from the *bubon galbanum.* This juice comes over in masses, composed of white, yellowish, brownish-yellow, and brown tears, unctuous to the touch, softening betwixt the fingers; of a bitterish, somewhat acrid, disagreeable taste, and a very strong smell; generally full of bits of stalks, leaves, seeds and other foreign matters.

Galbanum contains more of a resinous than gummy matter: one pound yields with alcohol upward of nine ounces and a half of resinous extract; but the gummy extract obtained by water from the same quantity, amounts only to about three ounces. The resin is hard, brittle, insipid, and inodorous: the gummy extract has somewhat of a nauseous relish, but could not be distinguished to be a preparation of galbanum. The whole smell, flavour, and specific taste of this juice, reside in an essential oil, which arises in distillation both with water and spirit, and gives a strong impregnation to both: from a pound of galbanum are obtained, by distillation with water, six drachms of actual oil, besides what is retained by the water. In this respect galbanum agrees with asafœtida, and differs from ammoniacum.

Galena. The black ore of lead.

Gall of Animals. See **Bile.**

Gall-stones. Calculous concretions are not unfrequently formed in the gall bladder, and sometimes occasion great pain in their passage through the ducts into the duodenum, before they are evacuated. Of these stones there are four different kinds.

1. The first has a white colour, and when broken, presents crystalline plates, or striæ, brilliant and white like mica, and having a soft greasy feel. Sometimes its colour is yellow or greenish; and it has constantly a nucleus of inspissated bile. Its sp. gravity is inferior to that of water: Gren found the specific gravity of one, 0.803. When exposed to a heat considerably greater than that of boiling water, this crystallized calculus softens and melts, and crystallizes again when the temperature is lowered. It is altogether insoluble in water; but hot alcohol dissolves it with facility. Alcohol, of the temperature of 167°, dissolves one-twentieth of its weight of this substance; but alcohol, at the temperature of 60°, scarcely dissolves any of it. As the alcohol cools, the matter is deposited in brilliant plates, resembling talc or boracic acid. It is soluble in oil of turpentine. When melted, it has the appearance of oil, and exhales the smell of melted wax; when suddenly heated, it evaporates altogether in a thick smoke. It is soluble in pure alkalis, and the solution has all the properties of soap. Nitric acid also dissolves it; but it is precipitated unaltered by water.

This matter, which is evidently the same with the crystals Cadet obtained from bile, and which he considered as analogous to sugar of milk, has a strong resemblance to spermaceti. Like that substance, it is of an oily nature, and inflammable; but it differs from it in a variety of particulars. Since it is contained in bile, it is not difficult to see how it may crystallize in the gall-bladder if it happen to be more abundant than usual; and the consequence must be a gall-stone of this species. Fourcroy found a quantity of the same substance in the dried human liver. He called it Adipocere.

2. The second species of biliary calculus is of a round or polygonal shape, often of a gray colour externally, and brown within. It is formed of concentric layers of a matter which seems to be inspissated bile; and there is usually a nucleus of the white crystalline matter at the centre. For the most part, there are many of this species of calculus in the gall-bladder together: indeed it is frequently filled with them. The calculi belonging to this species are often light and friable, and of a brownish-red colour. The gall-stones of oxen used by painters belong to this species. These are also adipocere.

3. The third species of calculi are most numerous of all. Their colour is often deep brown or green; and when broken, a number of crystals of the substance resembling spermaceti are observable, mixed with inspissated bile. The calculi belonging to these three species are soluble in alkalis, in soap ley, in alcohol, and in oils.

4. Concerning the fourth species of gall-stone, very little is known with accuracy. Dr. Saunders tells us, that he has met with some gall-stones insoluble both in alcohol and oil of turpentine, some of which do not flame, but become red, and consume to ashes like charcoal. Haller quotes several examples of similar calculi. Gall-stones often occur in the inferior animals, particularly in cows and hogs; but the biliary concretions of these animals have not hitherto been examined with much attention.

Soaps have been proposed as solvents for these calculi. The academy of Dijon has published the success of a mixture of essence of turpentine and ether.

Galls. These are the protuberances produced by the puncture of an insect on plants and trees of different kinds. Some of them are hard, and termed nut-galls; others are soft and spongy, and called berry-galls, or apple-galls. The best are the nut-galls of the oak, and those brought from Aleppo are preferred. These are not smooth on the surface, but tubercular, small, and heavy; and should have a bluish or blackish tinge.

Deyeux investigated the properties of galls with considerable care; and more lately Sir H. Davy has examined the same subject. The strongest infusion Sir H. Davy could obtain at 56° F. by repeated infusion of distilled water, on the best Aleppo galls, broken into small pieces, was of the specific gravity of 1.068. Four hundred grains of this infusion, evaporated at a heat below 200°, left 53 of solid matter, which consisted of about 0.9 tannin, and 0.1 gallic acid, united to a portion of extractive matter. One hundred grains of the solid matter left, by incineration, nearly 4¾, which were chiefly calcareous matter, mixed with a small portion of fixed alkali.

From 500 grains of Aleppo galls, Sir H. Davy obtained, by infusion as above, 185 grains of solid matter, which on analysis appeared to consist of tannin 130; mucilage, and matter rendered insoluble by evaporation, 12; gallic acid, with a little extractive matter, 31; remainder, calcareous earth and saline matter, 12.

The use of galls in dyeing is very extensive, and they are one of the principal ingredients in making ink. Powdered galls made into an ointment with hog's lard are a very efficacious application in piles. They are sometimes given internally as an astringent; and in the intermittents, where the bark has failed. The tubercles, or knots, on the roots of young oaks, are said to possess the same properties as the nut-galls, and to be produced in a similar manner.

For their acid, see **Acid (Gallic)**.

* **Galvanism.** The following article is chiefly extracted from a paper, which was read by me at the Glasgow Literary Society, December 10, 1818, and published in the Journal of Science and the Arts, of the following January. I have now subjoined a few further observations, on the application of voltaic electricity to the resuscitation of the suspended functions of life.

Convulsions accidently observed in the limbs of dead frogs, originally suggested to Galvani, the study of certain phenomena, which from him have been styled Galvanic. He ascribed these movements to an electrical fluid or power, innate in the living frame, or capable of being evolved by it, which he denominated animal electricity. The *Torpedo*, *Gymnotus*, and *Silurus Electricus*, fish endowed with a true electrical apparatus, ready to be called into action by an effort of their will, were previously known to the naturalist, and furnished plausible analogies to the philosopher of Bologna. Volta, to whom this science is indebted for the most brilliant discoveries on its principles, as well as for its marvellous apparatus, justly called by his name, advanced powerful arguments against the hypothesis of Galvani. He ascribed the muscular commotions, and other phenomena, to the excitation of common electricity, by arrangements previously unthought of by the scientific world; merely by the mutual contact of dissimilar bodies, metals, charcoal, and animal matter, applied either to each other, or conjoined with certain fluids. And at the present day, perhaps the only facts which seem difficult to reconcile with the beautiful theory of electro-motion, invented by the Pavian professor, are some experiments of Aldini, the nephew of the original discoverer.

In these experiments, neither metals nor charcoal were employed. Very powerful muscular contractions seem to have been excited in some of the experiments, by bringing a part of a warm-blooded, and of a cold-blooded animal, into contact with each other; as the nerve and muscle of a frog, with the bloody flesh of the neck of a newly decapitated ox. In other experiments, the nerves and muscles of the same animal seem to have operated Galvanic excitation; and again, the nerve of one animal acted with the muscle of another. He deduces from his experiments, an inference in favour of his uncle's hypothesis, that a proper animal electricity is inherent in the body, which does not require the assistance of any external agent, for its developement. Should we admit the reality of these results, we may perhaps venture to refer them to a principle analogous to Sir H. Davy's pile, or voltaic circuit of two dissimilar liquids and charcoal. This part of the subject is however involved in deep obscurity.

Many experiments have been performed, in this country and abroad, on the bodies of criminals, soon after their execution. Vassali, Julio, and Rossi made an ample set, on several bodies decapitated at Turin. They paid particular attention to the effect of galvanic electricity on the heart, and other involuntary muscles: a subject of much previous controversy. Volta asserted, that these muscles are not at all sensible to this electric power. Fowler maintained, that they were affected; but with difficulty and in a slight degree. This opinion was confirmed by Vassali; who further showed, that the muscles of the stomach, and intestines, might thus also be excited. Aldini, on the contrary, declared, that he could not affect the heart, by his most powerful galvanic arrangements.

Most of the above experiments were however made, either without a voltaic battery, or with piles, feeble in comparison with those now employed. Those indeed performed on the body of a criminal, at Newgate, in which the limbs were violently agitated; the eyes opened and shut; the mouth and jaws worked about, and the whole face thrown into frightful convulsions, were made by Aldini, with I believe, a considerable series of voltaic plates.

A circumstance of the first moment, in my opinion, has been too much overlooked in experiments of this kind,—that a muscular mass through which the galvanic energy is directly transmitted, exhibits very weak contractile movements, in comparison with those which can be excited by passing the influence along the principal nerve of the muscle. Inattention to this important distinction, I conceive to be the principal source of the slender effects hitherto produced in such experiments on the heart, and other muscles, independent of the will. It ought also to be observed, that too little distinction has been made between the positive and negative poles of the battery; though there are good reasons for supposing, that their powers on muscular contraction are by no means the same.

According to Ritter, the electricity of the positive pole augments, while the negative diminishes the actions of life. Tumefaction of parts is produced by the former; depression by the latter. The pulse of the hand, he says, held a few minutes in contact with the positive pole, is strengthened; that of the one in contact with the negative is enfeebled; the former is accompanied with a sense of heat, the latter with a feeling of coldness. Objects appear to a positively electrified eye, larger, brighter, and red; while to one negatively electrified, they seem smaller, less distinct, and bluish,—colours indicating opposite extremities of the prismatic spectrum. The acid and alkaline tastes, when the tongue is acted on in succession by the two electricities, are well known, and have been ingeniously accounted for by Sir H. Davy, in his admirable Bakerian Lectures. The smell of oxymuriatic acid, and of ammonia, are said by Ritter, to be the opposite odours, excited by the two opposite poles; as a full body of sound and a sharp tone are the corresponding effects on the ears. These experiments require verification.

Consonant in some respects, though not in all, with these statements, are the doctrines taught by a London practitioner, experienced in the administration of medical electricity. He affirms, that the influence of the electrical fluid of our common machines, in the cure of disease, may be referred to three distinct heads; first, the form of *radii*, when projected from a point positively electrified; secondly, that of a star, or the negative fire, concentred on a brass ball; thirdly, the Leyden explosion. To each of these forms he assigns a specific action. The first acts as a sedative, allaying morbid activity; the second as a stimulant; and the last has a deobstruent operation, in dispersing chronic tumours. An ample narrative of cases is given in confirmation of these general propositions. My own experience leads me to suppose, that the negative pole of a voltaic battery, gives more poignant sensations than the positive.

But, unquestionably, the most precise and interesting researches on the relation between voltaic electricity and the phenomena of life, are those contained in Dr. Wilson Philip's Dissertations in the Philosophical Transactions, as well as in his Experimental Inquiry into the Laws of the Vital Functions, more recently published.

In his earlier researches, he endeavoured to prove, that the circulation of the blood, and the action of the involuntary muscles, were independent of the nervous influence. In a late paper, read in January 1816, he showed the immediate dependence of the secretory functions on the nervous influence.

The eighth pair of nerves distributed to the stomach, and subservient to digestion, were divided by incisions in the necks of several living rabbits. After the operation, the parsley which they ate remained without alteration in their stomachs; and the animals, after evincing much difficulty of breathing, seemed to die of suffocation. But when in other rabbits, similarly treated, the galvanic power was transmitted along the nerve, below its section, to a disc of silver, placed closely in contact with the skin of the animal, opposite to its stomach, no difficulty of breathing occurred. The voltaic action being kept up for twenty-six hours, the rabbits were then killed, and the parsley was found in as perfectly digested a state, as that in healthy rabbits fed at the same time; and their stomachs evolved the smell peculiar to that of a rabbit during digestion. These experiments were several times repeated with similar results.

Hence it appears that the galvanic energy is capable of supplying the place of the nervous influence, so that while under it, the stomach, otherwise inactive, digests food as usual. I am not, however, willing to adopt the conclusion drawn by its ingenious author, that the "identity of galvanic electricity and nervous influence is established by these experiments." They clearly show a remarkable analogy between these two powers, since the one may serve as a substitute for the other. It might possibly be urged by the anatomist, that, as the stomach is supplied by twigs of other nerves, which communicate under the place of Dr. Philips' section of the *par vagum*, the galvanic fluid may operate merely as a powerful stimulus, exciting those slender twigs to perform such an increase of action, as may compensate for the want of the principal nerve. The above experiments were repeated on dogs, with like results; the battery never being so strong as to occasion painful shocks.

The removal of dyspnœa as stated above, led him to try galvanism as a remedy in asthma. By transmitting its influence from the nape of the neck to the pit of the stomach, he gave decided relief in every one of twenty-two cases, of which four were in private practice, and eighteen in the Worcester Infirmary. The power employed varied from ten to twenty-five pairs.

The general inferences deduced by him from his multiplied experiments, are, that voltaic electricity is capable of effecting the formation of the secreted fluids when applied to the blood, in the same way in which the nervous influence is applied to it; and that it is capable of occasioning an evolution of caloric from arterial blood. When the lungs are deprived of the nervous influence, by which their function is impeded, and even destroyed, when digestion is interrupted, by withdrawing this influence from the stomach, these two vital functions are renewed by exposing them to the influence of a galvanic trough. "Hence," says he, "galvanism seems capable of performing all the functions of the nervous influence in the animal economy; but obviously it cannot excite the functions of animal life, unless when acting on parts endowed with the living principle."

These results of Dr. Philip have been recently confirmed by Dr. Clarke Abel, of Brighton, who employed, in one of the repetitions of the experiments, a comparatively weak, and in the other a considerable power of galvanism. In the former, although the galvanism was not of sufficient power to occasion evident digestion of the food, yet the efforts to vomit, and the difficulty of breathing, constant effects of dividing the eighth pair of nerves, were prevented by it. These symptoms recurred when it was discontinued, and vanished on its reapplication. "The respiration of the animal," he observes, "continued quite free during the experiment, except when the disengagement of the nerves from the tinfoil, rendered a short suspension of the galvanism necessary during their readjustment." "The non-galvanized rabbit, breathed with difficulty, wheezed audibly, and made frequent attempts to vomit." In the latter experiment, in which the greater power of galvanism was employed, digestion went on as in Dr. Philips' experiments.—*Jour. Sc.* ix.

M. Gallois, an eminent French physiologist, had endeavoured to prove, that the motion of the heart depends entirely upon the spinal marrow, and immediately ceases when the spinal marrow is removed or destroyed. Dr. Philip appears to have refuted this notion, by the following experiments. Rabbits were rendered insensible by a blow on the occiput; the spinal marrow and brain were then removed, and the respiration kept up by artificial means: the motion of the heart, and the circulation, were carried on as usual. When spirit of wine, or opium, was applied to the spinal marrow or brain, the rate of the circulation was accelerated.

These general physiological views will serve, I hope, as no inappropriate introduction to the detail of the galvanic phenomena, exhibited here on the 4th of November, in the body of the murderer Clydesdale; and they may probably guide us to some valuable practical inferences.

The subject of these experiments was a middle-sized, athletic, and extremely muscular man, about thirty years of age. He was suspended from the gallows nearly an hour, and made no convulsive struggle after he dropped; while a thief, executed along with him, was violently agitated for a considerable time. He was brought to the anatomical theatre of our university in about ten minutes after he was cut down. His face had a perfectly natural aspect, being neither livid nor tumefied; and there was no dislocation of his neck.

Dr. Jeffray, the distinguished professor of anatomy, having on the preceding day requested me to perform the galvanic experiments, I sent to his theatre with this view, next morning, my *minor* voltaic battery, consisting of 270 pairs of four inch plates, with wires of communication, and pointed metallic rods with insulating handles, for the more commodious application of the electric power. About five minutes before the police officers arrived with the body, the battery was charged with a dilute nitro-sulphuric acid, which speedily brought it into a state of intense action. The dissections were skilfully executed by Mr. Marshall, under the superintendence of the professor.

Exp. 1. A large incision was made into the nape of the neck, close below the *occiput*. The posterior half of the *atlas vertebra* was then removed by bone forceps, when the spinal marrow was brought into view. A profuse flow of liquid blood gushed from the wound, inundating the floor. A considerable incision was at the same time made in the left hip, through the great gluteal muscle, so as to bring the sciatic nerve into sight; and a small cut was made in the heel. From neither of these did any blood flow. The pointed rod connected with one end of the battery, was now placed in contact with the spinal marrow, while the other rod was applied to the sciatic nerve. Every muscle of the body was immediately agitated with convulsive movements, resembling a violent shuddering from cold. The left side was most powerfully convulsed at each renewal of the electric contact. On moving the second rod from the hip to the heel, the knee being previously bent, the leg was thrown out with such violence, as nearly to overturn one of the assistants, who in vain attempted to prevent its extension.

Exp. 2. The left phrenic nerve was now laid bare at the outer edge of the *sterno-thyroideus* muscle, from three to four inches above the clavicle; the cutaneous incision having been made by the side of the sterno-cleido-mastoideus. Since this nerve is distributed to the diaphragm, and since it communicates to the heart through the eighth pair, it was expected, by transmitting the galvanic power along it, that the respiratory process would be renewed. Accordingly, a small incision having been made under the cartilage of the seventh rib, the point of the one insulating rod was brought into contact with the great head of the diaphragm, while the other point was applied to the phrenic nerve in the neck. This muscle, the main agent of respiration, was instantly contracted, but with less force than was expected. Satisfied, from ample experience on the living body, that more powerful effects can be produced in galvanic excitation, by leaving the extreme communicating rods in close contact with the parts to be operated on, while the electric chain or circuit is completed, by running the end of the wires along the top of the plates in the last trough of either pole, the other wire being steadily immersed in the last cell of the opposite pole, I had immediate recourse to this method. The success of it was truly wonderful. Full, nay, laborious breathing, instantly commenced. The chest heaved, and fell; the belly was protruded, and again collapsed, with the relaxing and retiring diaphragm. This process was continued, without interruption, as long as I continued the electric discharges.

In the judgment of many scientific gentlemen who witnessed the scene, this respiratory experiment was perhaps the most striking ever made with a philosophical apparatus. Let it also be remembered, that for full half an hour before this period, the body had been well nigh drained of its blood, and the spinal marrow severely lacerated. No pulsation could be perceived meanwhile at the heart or wrist; but it may be supposed, that but for the evacuation of the blood,—the essential stimulus of that organ,—this phenomenon might also have occurred.

Exp. 3. The supra-orbital nerve was laid bare in the forehead, as it issues through the supra-ciliary *foramen*, in the eyebrow: the one conducting rod being applied to it, and the other to the heel, most extraordinary grimaces were exhibited every time that the electric discharges were made, by running the wire in my hand along the edges of the last trough, from the 220th to the 270th pair of plates; thus fifty shocks, each greater than the preceding one, were given in two seconds: every muscle in his countenance was simultaneously thrown into fearful action; rage, horror, despair, anguish, and ghastly smiles, united their hideous expression in the murderer's face, surpassing far the wildest representations of a Fuseli or a Kean. At this period several of the spectators were forced to leave the apartment from terror or sickness, and one gentleman fainted.

Exp. 4. The last galvanic experiment consisted in transmitting the electric power from the spinal marrow to the ulnar nerve, as it passes by the internal condyle at the elbow; the fingers now moved nimbly, like those of a violin performer; an assistant, who tried to close the fist, found the hand to open forcibly, in spite of his efforts. When the one rod was applied to a slight incision in the tip of the fore-finger, the fist being previously clenched, that finger extended instantly; and from the convulsive agitation of the arm, he seemed to point to the different spectators, some of whom thought he had come to life.

About an hour was spent in these operations.

In deliberating on the above galvanic phenomena, we are almost willing to imagine, that if, without cutting into and wounding the spinal marrow and blood-vessels in the neck, the pulmonary organs had been set a-playing at first, (as I proposed), by electrifying the phrenic nerve, (which may be done without any dangerous incision), there is a probability that life might have been restored. This event, however little desirable with a murderer, and perhaps contrary to law, would yet have been pardonable in one instance, as it would have been highly honourable and useful to science. From the accurate experiments of Dr. Philip, it appears, that the action of the diaphragm and lungs is indispensable towards restoring the suspended action of the heart and great vessels, subservient to the circulation of the blood.

It is known, that cases of death-like lethargy, or suspended animation, from disease and accidents, have occurred, where life has returned, after longer interruption of its functions, than in the subject of the preceding experiments. It is probable, when apparent death supervenes from suffocation with noxious gases, &c. and when there is no organic læsion, that a judiciously directed galvanic experiment will, if any thing will, restore the activity of the vital functions. The plans of administering voltaic electricity hitherto pursued in such cases, are, in my humble apprehension, very defective. No advantage, we perceive, is likely to accrue from passing electric discharges across the chest, directly through the heart and lungs. On the principles so well developed by Dr. Philip, and now illustrated on Clydesdale's body, we should transmit along the channel of the nerves, that substitute for nervous influence, or that power which may perchance awaken its dormant faculties. Then, indeed, fair hopes may be formed of deriving extensive benefit from galvanism; and of raising this wonderful agent to its expected rank, among the ministers of health and life to man.

I would, however, beg leave to suggest another nervous channel, which I conceive to be a still readier and more powerful one, to the action of the heart and lungs, than the phrenic nerve. If a longitudinal incision be made, as is frequently done for aneurism, through the integuments of the neck at the outer edge of the *sterno-mastoideus* muscle, about half-way between the clavicle and angle of the lower jaw; then on turning over the edge of this muscle, we bring into view the throbbing carotid, on the outside of which, the *par vagum*, and great sympathetic nerve, lie together in one sheath. Here, therefore, they may both be directly touched and pressed by a blunt metallic conductor. These nerves communicate directly, or indirectly, with the phrenic; and the superficial nerve of the heart is sent off from the sympathetic.

Should, however, the phrenic nerve be taken, that of the left side is the preferable of the two. From the position of the heart, the left phrenic differs a little in its course from the right. It passes over the *pericardium*, covering the *apex* of the heart.

While the point of one metallic conductor is applied to the nervous cords above described, the other knob ought to be firmly pressed against the side of the person, immediately under the cartilage of the seventh rib. The skin should be moistened with a solution of common salt, or what is better, a hot saturated solution of sal ammoniac, by which means, the electric energy will be more effectually conveyed through the cuticle, so as to complete the voltaic chain.

To lay bare the nerves above described, requires, as I have stated, no formidable incision, nor does it demand more anatomical skill, or surgical dexterity, than every practitioner of the healing art ought to possess. We should always bear in mind, that the subject of experiment is at least insensible to pain; and that life is at stake, perhaps irrecoverably gone. And assuredly, if we place the risk and difficulty of the operations, in competition with the blessings, and glory consequent on success, they will weigh as nothing, with the intelligent and humane. It is possible, indeed, that two small brass knobs, covered with cloth moistened with solution of sal ammoniac, pressed above and below, on the place of the nerve, and the diaphragmatic region, may suffice, without any surgical operation: It may first be tried.

Immersion of the body in cold water accelerates greatly the extinction of life arising from suffocation; and hence less hopes need be entertained, of recovering drowned persons after a considerable interval, than when the vital heat has been suffered to continue with little abatement. None of the ordinary practices judiciously enjoined by the Humane Society, should ever on such occasions be neglected. For it is surely culpable to spare any pains which may contribute, in the slightest degree, to recal the fleeting breath of man to its cherished mansion.

My attention has been again particularly directed to this interesting subject, by a very flattering letter which I lately received, from the learned secretary of the Royal Humane Society.

In the preceding account, I had accidentally omitted to state a very essential circumstance relative to the electrization of Clydesdale. The paper indeed was very rapidly written, at the busiest period of my public prelections, to be presented to the society, as a substitute for the essay of an absent friend, and was sent off to London, the morning after it was read.

The positive pole or wire connected with the zinc end of the battery, was that which I applied to the nerve; and the negative, or that connected with the copper end, was that which I applied to the muscles. This is a matter of primary importance, as the following experiments will prove.

Prepare the posterior limbs of a frog, for voltaic electrization, leaving the crural nerves connected, as usual, to a detached portion of the spine. When the excitability has become nearly exhausted, plunge the limbs into the water of one wine glass, and the crural nerves with their pendent portion of spine, into that of the other. The edges of the two glasses, should be almost in contact. Then taking a rod of zinc in one hand, and a rod of silver (or a silver tea-spoon) in the other, plunge the former into the water of the limbs' glass, and the latter into that of the nerves' glass, without touching the frog itself, and gently strike the dry parts of the bright metals together. Feeble convulsive movements, or mere twitching of the fibres, will be perceived at every contact. Reverse now the position of the metallic rods; that is, plunge the zinc into the nerves' glass, and the silver into the other. On renewing the contact of the dry surfaces of the metal now, very lively convulsions will take place; and if the limbs are skilfully disposed in a narrowish conical glass, they will probably spring out to some distance. This interesting experiment may be agreeably varied in the following way, with an assistant operator: Let that person seize in the moist fingers of his left hand, the spine and nervous cords of the prepared frog; and in those of the right hand, a silver rod; and let the other person lay hold of one of the limbs with his right hand, while he holds a zinc rod in the moist fingers of the left. On making the metallic contact, feeble convulsive twitchings will be perceived, as before. Holding still the frog as above, let them merely exchange the pieces of metal. On renewing the contacts now, lively movements will take place, which become very conspicuous, if one limb be held nearly horizontal, while the other hangs freely down. At each touch of the voltaic pair, the drooping limb will start up, and strike the hand of the experimenter.

It is evident, therefore, that for the purposes of resuscitating dormant irritability of nerves, or contractility of their subordinate muscles, the positive pole must be applied to the former, and the negative to the latter. I need scarcely suggest, that to make the above experiments analogous to the condition of a warm-blooded animal, apparently dead, the frog must have its excessive voltaic sensibility considerably blunted, and brought near the standard of the latter, before beginning the experiments. Otherwise, that animal electroscope, incomparably more delicate than the gold leaf condenser, will give very decided convulsions with either pole.

At the conclusion of the article *Caloric*, I have taken the liberty of suggesting some simple and ready methods of supplying warmth to the body of a drowned person.*

† GALVANIC DEFLAGRATOR. I have given this name to a galvanic apparatus, which I contrived last autumn, (1820), and of which a plate is annexed at the end of this work. It differs from other galvanic batteries, 1st, In consisting of concentric coils, instead of flat plates; and in being so constructed, as to permit of a simultaneous immersion of the whole series at the same instant. 2dly, Under one of its forms, in not having the pairs of plates insulated, but placed in two troughs, each containing forty. In consequence of the simultaneous action, the effects of this deflagrator far exceeded those of voltaic piles or troughs, of equal number and extent of surface. The light, given out by the combustion of iron wire and charcoal, was so intense as to affect the eyes of spectators painfully at fifty feet distance.

In its uninsulated form, it produced, with fresh water, a sensation in the back of the hand, almost intolerable. For further particulars, I refer to Silliman's Journal for February, 1821.†

GAMBOGE is a concrete vegetable juice,

the produce of two trees, both called by the Indians caracapulli (gambogia gutta Lin.), and is partly of a gummy and partly of a resinous nature. It is brought to us either in form of orbicular masses, or of cylindrical rolls of various sizes; and is of a dense, compact and firm texture, and of a beautiful yellow. It is chiefly brought to us from Cambaja, in the East Indies, called also Cambodja, and Cambogia; and hence it has obtained its name of cambadium, cambogium, gambogium.

It is a very rough and strong purge; it operates both by vomit and stool, and both ways with much violence, almost in the instant in which it is swallowed, but yet, as it is said, without griping. The dose is from two to four grains as a cathartic; from four to eight grains prove emetic and purgative. The roughness of its operation is diminished by giving it in a liquid form sufficiently diluted.

This gum-resin is soluble both in water and in alcohol. Alkaline solutions possess a deep red colour, and pass the filter. Dr. Lewis informs us, that it gives a beautiful and durable citron-yellow stain to marble, whether rubbed in substance on the hot stone, or applied, as dragon's blood sometimes is, in form of a spirituous tincture. When it is applied on cold marble, the stone is afterward to be heated to make the colour penetrate.

It is chiefly used as a pigment in water colours, but does not stand.

Gangue. The stones which fill the cavities that form the veins of metals are called the gangue, or matrix of the ore.

* **Garnet.** Professor Jameson divides this mineral genus into 3 species; the *pyramidal* garnet, *dodecahedral* garnet, and *prismatic* garnet.

I.—Pyramidal contains 3 sub-species, Vesuvian, Egeran, and Gehlenite, which see.

II.—*Dodecahedral* garnet contains 9 sub-species. 1. Pyreneite. 2. Grossulare. 3. Melanite. 4. Pyrope. 5. Garnet. 6. Allochroite. 7. Colophonite. 8. Cinnamon-stone. 9. Helvin.

III.—Prismatic garnet; the grenatite.

We shall treat here only of the garnet, proper. Of this sub-species, we have two kinds, the precious and common.

Precious or noble garnet. Colours dark red, falling into blue. Seldom massive, sometimes disseminated, most commonly in roundish grains, and crystallized. 1. In the rhomboidal dodecahedron, which is the primitive form; 2. Do. truncated on all the edges; 3. Acute double eight-sided pyramid; and 4. Rectangular four-sided prism. The surface of the grains is generally rough, uneven, or granulated; that of the crystals is always smooth. Lustre externally glistening; internally shining, bordering on splendent. Fracture conchoidal. Sometimes it occurs in lamellar distinct concretions. Transparent or translucent. Refracts single. Scratches quartz, but not topaz. Brittle. Rather difficultly frangible. Sp. gr. 4.0 to 4.2. Its constituents are, silica 39.66, alumina 19.66, black oxide of iron 39.68, oxide of manganese 1.80.—*Berzelius.* Before the blow-pipe it fuses into a black enamel, or scoria. It occurs imbedded in primitive rocks, and primitive metalliferous beds. It is found in various northern counties in Scotland; in Norway, Lapland, Sweden, Saxony, France, &c. It is cut for ring-stones. Coarse garnets are used as emery for polishing metals. The following vitreous composition imitates the garnet very closely:

Purest white glass, 2 ounces
Glass of antimony, 1 ounce
Powder of Cassius, 1 grain
Manganese, 1 grain.—*Jameson.*

The garnets of Pegu are most highly valued.

Common garnet.—Brown and green are its most common colours. Massive, but never in grains or angular pieces. Sometimes crystallized, and possesses all the forms of the precious garnet. Lustre, shining or glistening. Fracture, fine grained uneven. More or less translucent; the black kind nearly opaque. It is a little softer than precious garnet. Rather difficultly frangible. Sp. gr. 3.7. Before the blow-pipe it melts more easily than precious garnet. Its constituents are 38 silica, 20.6 alumina, 31.6 lime, 10.5 iron.—*Vauquelin.* It occurs massive or crystallized in drusy cavities, in beds, in mica-slate, in clay-slate, chlorite-slate, and primitive trap. It is found at Kilranelagh and Donegal in Ireland; at Arendal and Drammen in Norway, and in many other countries. On account of its easy fusibility and richness in iron, it is frequently employed as a flux in smelting rich iron ores. It is sometimes used instead of emery by lapidaries.—*Jameson.**

* **Gas.** This name is given to all permanently elastic fluids, simple or compound, except the atmosphere, to which the term Air is appropriated.

The solid state, is that in which, by the predominance of the attractive forces, the particles are condensed into a coherent aggregate; the gaseous state, is that in which the repulsive forces have acquired the ascendency over the attractive; and the liquid condition represents the equilibrium of these two powers. Vapours are elastic fluids, which have no permanence; since a moderate reduction of temperature causes them to assume the liquid or solid aggregation.

Cohesive attraction among homogeneous

particles, is the great antagonist to chemical affinity, the attraction of composition, the force which tends to bring into intimate union, heterogeneous particles. Hence the juxtaposition of two solids, of a solid and a liquid, or even of two liquids, may never determine their chemical combination, however strong their reciprocal affinity shall be.

In the case of two liquids, or a liquid and a solid, mere juxtaposition requires, that the denser body be undermost, and that no disengagement of gas, or external vibration, agitate the surfaces in contact. Hence those world framers, who ascribe the saltness of the sea to supposed beds of rock salt at its bottom, have still the phenomenon of the strong impregnation of the surface to explain; for the profound tranquillity which is known to reign at very moderate depths in this mighty mass, would forever prevent the diffusion of the saturated brine below, among the light waters above. Or if this tranquillity be disputed, then progressive density from above downwards should be found, and continually increasing impregnation. Now none of these results has occurred. But with gases in contact, there is no obstacle from cohesive attraction, to the exertion of their reciprocal affinities. Hence, however feeble these may be, they never fail, sooner or later, to cause an intimate mixture of different gases, in which the ultimate particles approach within the limit corresponding to their reciprocal action. The difference of density may delay, but cannot prevent uniform diffusion. Thus we see that known powers can account for the phenomena. There is no need therefore of having recourse to the strange hypothesis of Mr. Dalton, that one gas is a neutral unresisting void with regard to another, into which it will rush by its innate expansive force. But of this fancy sufficient notice has been taken in the article Air (Atmospheric.)

The principle of gaseous combination, first broached in the neglected treatise of Mr. Higgins, but since developed with consummate sagacity from the original researches of M. Gay-Lussac, has thrown a new light on pneumatic chemistry, which has been reflected into all its mysterious departments, of animal and vegetable analysis. Having given the details under the article *Equivalents* (*Chemical*), we shall merely state in this place, that the combinations of gaseous bodies, are always effected in simple ratios of the volumes, so that if we represent one of the terms by unity, or 1, the other is 1, 2, or at most 3. Thus ammoniacal gas neutralizes exactly a volume equal to its own, of the gaseous acids. It is hence probable, that if the alkalis and acids were in the elastic state, they would all combine, each in equal volume with another, to produce neutral salts. The capacity of saturation of the acids and alkalis, measured by volumes, would then be the same; and perhaps this would be the best manner of estimation. In the following tables of gaseous combination, bodies naturally in the solid state, like sulphur, carbon and iodine, will be referred to their gaseous densities, or the bulks which they occupy relative to their weights, when diffused by chemical combination among the particles of a permanently elastic fluid. This view of the subject, first introduced by M. Gay-Lussac, and happily exemplified in his excellent memoir on iodine, will simplify our representation of many compounds. Finally, the apparent contractions or condensations of volume, which gases suffer by their reciprocal affinity, have also simple ratios with the volume of one of them; a property peculiar to gaseous bodies. We shall distribute under the following heads, our general observations on gases. 1. Tabular views of the densities, and combining ratios of the gases. 2. A description of their general habitudes with solids and liquids. 3. An account of the principal modes of analyzing gaseous mixtures. 4. Of gasometry, or the measurement of the density and volume of gases.

1. We are indebted to Dr. Prout for an able memoir on the relation between the specific gravities of bodies in their gaseous state, and the weights of their atoms, or prime equivalents, inserted in the sixth volume of the Annals of Philosophy. His observations are founded on M. Gay-Lussac's doctrine of volumes. Dr. Prout considers atmospheric air as a chemical compound, constituted by bulk of four volumes of azote and one of oxygen; and, reckoning the atom of oxygen as 10, and that of azote as 17.5, it will be found to consist of one atom of oxygen, and two atoms of azote, or per cent of oxygen 22.22
Azote 77.77

Though almost all experiments have hitherto led us to regard the atmosphere as containing 21 volumes in the 100 of oxygen, we must in this view, ascribe the excess of one per cent to an error of observation. Now, it is not improbable, that in the explosive eudiometer with hydrogen over mercury, or in the nitrous gas eudiometer over water, one per cent of azote may be pretty uniformly condensed.

Calling the prime equivalent of oxygen, 1.000, and that of azote 1.75, as deduced both from nitric acid and ammonia, we may easily calculate the specific gravities of these two gaseous elements of the atmospheric compound, itself being represented in sp. gr. by 1.00, and in the relative *weights* of its constituents, by $1.00 + \overline{1.75 \times 2}$; or $22.22 + 77.77$.

The ancient problem of Archimedes, for determining the fraud of the goldsmith, in making king Hiero's crown, which is so important in chemistry for computing the mean density of a compound, the specific gravities of whose two constituents are given; and for thence enabling us, by comparing that result, with the density found by experiment, to discover the change of volume due to the chemical action, is of peculiar value in pneumatic investigations. It will enable us to solve, without difficulty, the two following problems:—

1st, Having given the specific gravity of a mixed gas, and the specific gravities of its two constituent gases, to determine the volume, and consequently the quantity of each, present in the mixture.

2d, Having given the specific gravity of a mixed gas, and the proportions by weight and volume of its constituents, to determine the specific gravities of each of its constituents. In both cases, no chemical condensation or expansion is supposed, and only two gases are concerned.

1st, Let d be the sp. gr. of the denser gas;
l of the lighter gas;
m mixed gas;
x the volume of the denser gas;
y of the lighter gas;
v total volume of the compound.

Then $x = \dfrac{v(m-l)}{(d-m)+m-l}$, and $y = \dfrac{v(d-m)}{(d-m)+(m-l)}$

from one or other of which formulæ, the volume of one or other constituent may be found; and by multiplying the volume by the specific gravity, its weight is given. The same formula is stated in words under the article *Coal Gas*.

2d, When the specific gravities of the components are sought; the specific gravity of the compound, as well as the volume and weight of each component being given, we have the following formula:—

Let x be the sp. gr. of that whose weight is a and volume m.
y be the sp. gr. of that whose weight is b and volume n.

Then $\dfrac{mx+ny}{m+n} = s$, the sp. gr. of the compound whose weight $= 1$.

But the volume of one body multiplied into its specific gravity, is to the volume of another, multiplied into its specific gravity, as the weight of the first, is to that of the second; or

$$mx : ny :: a : b$$

And $m+n-ny = \dfrac{any}{b}$, if $s = 1$.

Whence $y = \dfrac{(m+n)b}{an+bn}$,

And $x = \dfrac{m+n-ny}{m}$.

Dr. Prout has very ingeniously applied this formula, to the determination of the specific gravities of oxygen and azote, which are,

Oxygen,	1.1111
Azote,	0.9722

His investigation of the specific gravity of hydrogen from that of ammonia, is conducted on principles still less disputable. The mean of the experimental results obtained by MM. Biot and Arago and Sir H. Davy on ammoniacal gas, is 0.5902. Now it has been demonstrated, that 2 volumes of it are resolvable into 4 volumes of constituent gases, of which 3 volumes are hydrogen and 1 azote. Hence, if from double the specific gravity of ammonia, we subtract the specific gravity of azote, the remainder divided by 3 will be the specific gravity of hydrogen. Or, putting the same thing into an algebraic form, on the principle that the sum of the weights divided by the sum of the volumes, gives the specific gravity of the mixture; let x be the specific gravity of hydrogen, then experiment shows, that $\dfrac{3x+0.9722}{2} = 0.5902$; Whence $x = \dfrac{\overline{2\times0.5902}-0.9722}{3} = 0.0694$. The density of hydrogen therefore is to that of azote, atmospherical air, and oxygen, as 1 to 14, 1 to 14.4, and 1 to 16, respectively.

And with regard to muriatic acid gas, it is well known to result from the union of chlorine and hydrogen in equal volumes, without any condensation; therefore if we call the sp. gr. of the compound gas 1.278, and from the double of that number deduct the sp. gr. of hydrogen, we shall have the sp. gr. of chlorine $= 1.278 \times 2 - 0.0694 = 2.4866$, which may be converted into the even number 2.5 without any chance of error. See *Sect. IV.*

In the common tables of equivalent ratios, adapted to the hypothesis that water is a compound of one atom of oxygen and one of hydrogen, or of half a volume of the former and one volume of the latter, we must compute the ratios of gaseous combination, among different bodies, by multiplying the weight of their atom or their prime equivalents by half the sp. gr. of oxygen $= 0.5555$. If the volume and sp. gr. of hydrogen were reckoned unity, then the doctrine of volumes and prime equivalents would coincide.

General Table of Gaseous Bodies, by DR. URE.

NAMES.	*Sp. gr.* *air* = 1.00	*Weight of* 100 *cubic inches.*	*Weight of prime equiv. oxygen* = 1.	*Constituents by volume.*	*Resulting volume.*	*Constituent prime equivalents.*
Hydrogen - - - - - -	0.0694	2.118	0.125			
Carbon - - - - - - -	0.4166	12.708	0.750			
Subcarb. hydrogen -	0.5555	17.000	1.000	2 hyd.+1 carb.	1	2 hyd.+1 carb.
Ammonia - - - - - -	0.5902	18.000	2.125	3 hyd.+1 azot.	2	3 hyd.+1 azote
Steam of water - - -	0.625	19.062	1.125	2 hyd.+1 oxy.	1½	1 hyd.+1 oxyg.
Phosphorus - - - - -	0.833	25.42	1.500			
Phosphur. hydrogen -	0.902	27.47	1.625	1 phos.+1 hyd.	1	1 phos.+1 hyd.
Subphos. hydrogen - -	0.9722	29.65	1.750	1 phos.+2 hyd.	1	1 phos.+2 hyd.
Carbonous oxide - -	0.9722	29.65	1.750	2 carb.+1 oxy.	1½	1 carb.+1 oxyg.
Carburetted hydrogen -	0.9722	29.65	0.875	1 carb.+1 hyd.	½	1 carb.+1 hyd.
Azote - . - - - - -	0.9722	29.65	1.750			
Prussic acid - - - -	0.9374	28.59	3.375	1 cyan.+1 hyd.	2	1 cyan.+1 hyd.
Atmospheric air - - -	1.0000	30.519	4.500	1 oxy.+4 azot.	5	1 oxyg.+2 azote
Deutoxide of azote, -	1.0416	31.77	3.750	1 oxy.+1 azot.	2	2 oxyg.+1 azote
Oxygen - - - - - -	1.1111	33.888	1.000			
Sulphur - - - - - -	1.1111	33.888	2.000			
Sulphuretted hydrogen	1.1805	36.006	2.125	1 hyd.+1 sulp.	1	1 hyd.+1 sulph.
Muriatic acid - - -	1.2840	39.183	4.6125	1 hyd.+1 chlo.	2	1 hyd.+1 chlor.
Carbonic acid - - -	1.5277	46.596	2.750	1 carb.+1 oxy.	1	1 carb.+2 oxyg.
Protoxide of azote - -	1.5277	46.596	2.750	1 oxy.+2 azote	1½	1 oxyg.+1 azote
Alcohol vapour - - -	1.6133	49.20	2.875	1 ol. gas+1 wa.	1	2 ol. gas+1 water
Cyanogen - - - - - -	1.8055	55.07	3.25	2 carb.+1 azote	1	2 carb.+1 azote
Chloroprussic acid - -	2.1527	65.69	7.75	1 cya.+1 chlo.	2	1 cyan.+1 chlor.
Muriatic ether - - -	2.219	67.68	10.375	1 mur.+2 alco.	2	1 mu. acid+2 alc.
Sulphurous acid - - -	2.222	67.77	4.000	1 oxy.+1 sulp.	1	2 oxyg.+1 sulph.
Deutoxide of chlorine -	2.361	72.0	9.50	2 oxy.+1 chlo.	2	1 chlor.+4 oxyg.
Fluoboric acid - - -	2.371	72.312	8.500			
Protoxide of chlorine -	2.44	74.42	5.50	2 oxy.+4 chlo.	5	1 oxyg.+1 chlor.
Chlorine - - - - - -	2.500	76.25	4.50			
Sulphuric ether vapour	2.586	78.87	2.875	2 olef.+1 wat.	1	4 olef.+1 water
Nitrous acid - - - -	2.638	80.48	4.75	3 oxy.+2 azote	2	3 oxyg.+1 azote
Sulphuret of carbon -	2.644	80.66	4.750	2 carb.+4 sulp.	2	2 sulph.+1 carb.
Sulphuric acid - - -	2.777	84.72	5.000	3 oxy.+2 sulp	2	3 oxyg.+1 sulph.
Chlorocarbonous acid -	3.472	105.9	6.25	1 chl.+1 car. ox	2	1 chlor.+1 car. ox.
Sal ammoniac - - -	3.746	114.3	6.75	2 am.+2 mur.	1	1 am.+1 mu. acid
Nitric acid - - - -	3.75	114.37	6.75	5 oxy.+2 azote	2	5 oxyg.+1 azote
Hydriodic acid - - -	4.340	132.37	15.625	1 hyd.+1 iodin.	2	1 hyd.+1 iodine
Oil of turpentine - -	5.013	152.9				
Chloric acid - - - -	5.277	160.97	9.5	3 oxy.+2 chlo.	2	5 oxyg.+1 chlor.
Fluoborate of ammonia	5.902	180.	10.625	2 am.+2 fluob.	1	1 am.+1 fluobor.
Subfluob. ammonia - -	7.10	216.7	12.750	4 am.+2 fluob.	1	2 am.+1 fluobor.
Tritosubfluob. ammonia	8.26	252.	14.875	6 am.+2 fluob.	1	3 am.+1 fluobor.
Fluosilicate of ammonia				2 am +1 acid.		

In the preceding table I have endeavoured to assemble the principal features of gaseous combination. For the properties of these 43 different gases, see the separate articles in the Dictionary.

II. Of the general habitudes of gaseous matter with solids and liquids. Mr. Dalton has written largely on these relations; but his results are so modified by speculation, that it is difficult to distinguish fact from hypothesis. Dr. Henry, however, made some good researches on the subject of this division, but they have since been so much extended and improved by M. de Saussure, that I shall take his elaborate researches for my guide. His Memoir on the absorption of the gases by different bodies was originally read to the Geneva Society on the 16th April 1812, and appeared in Gilbert's Annalender Physik for July 1814, from which it was translated into the 6th volume of the Annals of Philosophy.

1. Of the absorption of unmixed gases by solid bodies.

Of all solid bodies charcoal is the most remarkable in its action on the gases. In M. de Saussure's experiments, the red-hot charcoal was plunged under mercury, and introduced, after it became cool, into the gas to be absorbed, without ever coming into contact with atmospherical air.

Table of the Volumes of Gases absorbed by one volume of

GASES.	*Charcoal.*	*Meerschaum.*	*Adhesive slate.*	*Lignif. asbestus.*	*Saxon hydroph.*	*Quartz.*
Ammonia,	90	15	11.3	12.75	64	10
Muriatic acid,	85	—	—	—	17	—
Sulphurous acid,	65	—	—	—	7.37	—
Sulphuretted hydrogen,	55	11.7	—	—	—	—
Nitrous oxide,	40	3.75	—	—	—	—
Carbonic acid,	35	5.26	2.	1.7	1 0	0.6
Olefiant gas,	35	3.70	1.5	1.7	0.8	0.6
Carbonic oxide,	9.42	1.17	0.55	0.58	—	—
Oxygen,	9.25	1.49	0.7	0.47	0.6	0.45
Azote,	7.5	1.6	0.7	0.47	0.6	0.45
Oxycarburetted hydrogen from moist charcoal,	5.0	0.85	0.55	0.41	—	—
Hydrogen,	1.75	0.44	0.48	0.31	0.4	0.37

The absorption was not increased by allowing the charcoal to remain in contact with the gases after 24 hours; with the exception of oxygen, which goes on condensing for years, in consequence of the slow formation and absorption of carbonic acid. If the charcoal be moistened, the absorption of all those gases that have not a very strong affinity for water, is distinctly diminished. Thus boxwood charcoal, cooled under mercury, and drenched in water while under the mercury, is capable of absorbing only 15 volumes of carbonic acid gas; although, before being moistened, it could absorb 35 volumes of the same gas. Dry charcoal, saturated with any gas, gives out, on immersion in water, a quantity corresponding to the diminution of its absorbing power. During the absorption of gas by charcoal, an elevation of temperature takes place, proportional to the rapidity and amount of the absorption. The vacuum of the air-pump seems to possess the same influence as heat, in rendering charcoal capable of absorbing gaseous matter. A *transferrer* with a small jar containing a piece of charcoal was exhausted, and being then plunged into a pneumatic trough, was filled with mercury. The charcoal was next introduced into a gas, and absorbed as much of it, as after having been ignited. As the rapid absorption of carbonic acid gas by charcoal can raise the thermometer 25°, so its extraction by the air-pump, sinks it 7.5°.

Though charcoal possesses the highest absorbent power, yet it is common to all bodies which possess a certain degree of porosity, after they have been exposed to the action of the air-pump. Meerschaum, like charcoal, absorbs a greater bulk of rare than dense gas. Dried woods, linen threads, and silks, also absorb the gases. Of ammonia, hazel absorbs 100 volumes, mulberry 88, linen thread 68, silk 78; of carbonic acid, in the above order, 1.1, 0.46, 0.62, 1.1; of this gas, fir absorbed 1.1, and wool 1.7.

The rate of absorption of different gases, appears to be the same, in all bodies of similar chemical properties. All the varieties of asbestus condense more carbonic acid gas, than oxygen gas; but woods condense more hydrogen than azote. Yet the condensations themselves in different kinds of asbestus, or wood, or charcoal, are very far from being equal. Ligniform asbestus absorbs a greater volume of carbonic acid gas, than rock-cork; so does hydrophane than the swimming quartz of St. Ouen, and the quartz of Vauvert; and the absorption of gases by boxwood charcoal, is much greater than by fir charcoal. These differences are not in the least altered, if, instead of equal volumes, equal weights of charcoal be employed. It is curious that a piece of solid charcoal absorbs 7½ volumes, and the same reduced into fine powder absorbs only three volumes. The absorbing power of most kinds of charcoal increases as the specific gravity increases; and it is obvious, that the pores must become smaller and narrower with the increase of density. Charcoal from cork, of a specific gravity not exceeding 0.1, absorbed no sensible quantity of atmospheric air. Charcoal from fir, sp. gr. 0.4, absorbed 4½ times its volume of atmospherical air; that from boxwood, sp. gr. 0.6, absorbed 7½ of air; and pit-coal of vegetable origin from Russiberg, sp. gr. 1.326, absorbed 10½ times its volume of air. But, as the density augments, we arrive at a limit, when the pores become too small to allow gases to enter. Thus, the *black-lead* of Cumberland, containing 0.96 of carbon, sp. gr. 2.17, produces no alteration on atmospherical air. But this correspondence between the power of absorbing, and the specific gravity, is only accidental. Accurate experiments show remarkable deviations from this rule. The different kinds of charcoal, whether of similar or dissimilar sp. gravities, always differ from each other in their organization. They cannot be considered as resembling a sponge, whose pores and density may be modified by pressure.

On the whole, it appears that the property of condensing gases, possessed by some solids, is within certain limits, in the inverse ratio of the internal diameter of the pores of the absorbing bodies. But besides the porosity, there are two other circumstances which must be attended to in these absorptions: 1. The different affinities which exist between the gases and the solid bodies; and, 2. The power of expansion of the gases, or the opposition they make to their condensation, at different degrees of heat and atmospherical pressure.

The experiments hitherto described relate to the absorption of a single gas, not mixed with any other. But, when a piece of charcoal saturated with either oxygen, hydrogen, azote, or carbonic acid, is put into another gas, it allows a portion of the first to escape, in order to absorb into its pores a portion of the second gas. The volume of gas thus expelled from charcoal by another gas, varies according to the proportion in which both gases exist in the unabsorbed residue. The quantity expelled is greater, the greater the excess of the expelling gas. Yet it is not possible, in close vessels, to expel the whole of one gas, out of charcoal, by means of another; a small quantity always remains in the charcoal.

Two gases, united by absorption in charcoal, often experience a greater condensation than each would in a separate state. For example, the presence of oxygen gas in charcoal facilitates the condensation of hydrogen gas; the presence of carbonic acid gas, or of azote, facilitates the condensation of oxygen gas; and that of hydrogen, the condensation of azote. Yet, this effect does not take place, in all cases, with the four gases now mentioned; for the presence of azote in charcoal does not promote the absorption of carbonic acid gas. When the absorption of one of the four named gases, has been facilitated by another of them, no perceptible combination between the two takes place, at least within the interval of some days. So, for example, notwithstanding the assertion of Rouppe and Van Noorden, no separation of water appears, when charcoal saturated with hydrogen at the common temperatures is put into oxygen gas; or when the experiment is reversed. Nor has azote and hydrogen been united in this way into ammonia, or azote and oxygen into nitric acid.

2. Absorption of *gases* by *liquids.*

"That all gases are absorbed by liquids," says M. de Saussure, "and that most of them are again separated by heat, or the diminution of external pressure, has been long known. We now possess accurate results respecting the rate of this absorption. For a set of careful and regular experiments on this subject, we are indebted to Dr. Henry of Manchester. Mr. Dalton has a little altered some of these results; and, by means of them, has contrived a theory which not only explains the absorption of gases by water, but by all other liquids; but it is in opposition to most of the results which I have obtained by means of solid porous bodies."

The following table exhibits the volumes of the different gases, absorbed, according to the accurate experiments of Saussure, by 100 volumes of

Gases.	*Water.*	*Alcohol sp. gr.* 0.84.	*Naphtha sp. gr.* 0.784.	*Oil of lavender sp. gr.* 0.88.	*Olive oil.*	*Satur. solution mur. pot.*
Sulphurous acid,	4378	11577				
Sulphuretted hydrogen,	253	606				
Carbonic acid,	106	186	169	191	151	61
Nitrous oxide,	76	153	254	275	150	21
Olefiant gas,	15.3	127	261	209	122	10
Oxygen gas,	6.5	16.25	—	—	—	—
Carbonous oxide,	6.2	14.50	20	15.6	14.2	5.2
Oxycarburetted hydrogen,	5.1	7.0				
Hydrogen,	4.6	5.1				
Azote,	4.1	4.2				

The above liquids were previously freed from air, as completely as possible, by long and violent boiling. But those which would have been altered or dissipated by the application of such a heat, as oils, and some saline solutions, were freed from air by means of the air-pump. To produce a speedy and complete absorption, a large quantity of those gases which are absorbed only in small quantities by liquids, as azote, oxygen, and hydrogen, was put, with a small quantity of the liquid, into a flask, which was furnished with an excellent ground stopper. The flask was agitated for a quarter of an hour. This method is difficult and requires much attention. With respect to all the gases of which the liquid absorbs more than 1-7th of its bulk, M. de Saussure proceeded in the following manner:—He placed them over mercury, in a tube fully 1⅓ inches internal diameter, and let up a column of the absorbing liquid, from about 1¾ to 2⅓ inches long. The absorption was promoted by agitation, and its quantity was not determined till the gas and the liquid had been in contact for several days.

A hundred volumes of water absorb about five volumes of atmospherical air, when the mass of air is very great, in comparison of that of the water.

"From these experiments," says M. de Saussure, "it appears, contrary to Dalton's assertion, that the absorption of gases, by different liquids, not glutinous, as water and alcohol, is very far from being similar. The alcohol, as we see, often absorbs twice as much of them, as the water does. In gases which are absorbed in small quantities, this difference is not so striking, because, with respect to them, the absorptions of the alcohol can be less accurately determined, on account of the air which still remains in it, after being boiled.

"These experiments agree no better with the law, which Dalton thinks he has ascertained in the absorption of different gases by one and the same liquid; for I find too great a difference between the quantity of carbonic acid, sulphuretted hydrogen, and nitrous oxide gases, absorbed by the same liquids (which Dalton considers as completely equal), to be able to ascribe it to errors in the experiments."

3. Of the influence of chemical affinity on the absorption of the gases.

If such an influence did not exist, the gases would be absorbed by all liquids in the same order. Table of the volumes of gases absorbed by 100 volumes of

Names of gases.	*Naph. sp. gr.* 0.784.	*Oil of lav. sp. gr.* 0.88.	*Olive oil.*	*Solution mur. pot.*
Olefiant gas,	261	209	122	10
Nitrous oxide,	254	275	150	21
Carbonic acid,	169	191	151	61
Carbonous oxide,	20	15.6	14.2	5.2

"It follows," says M. de Saussure, "from these experiments, that in liquids, as well as in solid bodies, great differences take place, in the order in which gases are absorbed by them; and that, in consequence, these absorptions are always owing to the influence of chemical affinity. Solid bodies appear, under the same circumstances, to produce a greater condensation of all gases, in contact with which they are placed, than liquid bodies do. I have met with no liquid which absorbs so great a volume of carbonic acid, olefiant gas, azotic gas, carbonous oxide, and nitrous oxide, as charcoal and meerschaum do. The difference is probably owing to this circumstance, that liquids, in consequence of the great mobility of their parts, cannot compress the gases so strongly as is necessary for greater condensation, certain cases excepted, when very powerful chemical affinities come to their assistance; as, for example, the affinity of ammonia and muriatic acid for water. Only in these rare cases do liquids condense a greater quantity of gases than solid bodies. According to Thomson, water in the mean temperature of the atmosphere absorbs 516 times its bulk of muriatic acid gas, and 780 times its bulk of ammoniacal gas." In the articles *muriatic acid* and *ammonia* in this Dictionary, I have shown these determinations of Dr. Thomson to be erroneous.

4. Influence of the viscidity, and the specific gravity of liquids on their absorption of gases. Carbonic acid gas was placed in contact with one volume of the different liquids. The temperature in all the experiments was 62.5°.

Liquids.	*Sp. gr.*	*Volume of car. acid gas absorbed.*	100 *parts of the solution, contain*
Alcohol,	0.803	2.6	
Sulph. ether,	0.727	2.17	
Oil of lavender,	0.880	1.91	
Oil of thyme,	0.890	1.88	
Spirit of wine,	0.840	1.87	
Rectified naphtha,	0.784	1.69	
Oil of turpentine,	0.860	1.66	
Linseed oil,	0.940	1.56	
Olive oil,	0.915	1.51	
Water,	1.000	1.06	
Sal ammoniac,	1.078	0.75	27.53 crystals, sat. sol.
Gum arabic,	1.092	0.75	25. gum,
Sugar,	1.104	0.72	25. sugar,
Alum,	1.047	0.70	9.14 cry. al. sat. sol.
Sulphate of potash,	1.077	0.62	9.42 c. s. sat. sol.
Muriate of potash,	1.168	0.61	26.0 c. s. sat. sol.
Sulphate of soda,	1.105	0.58	11.14 dry salt, sat. sol.
Nitre,	1.139	0.57	20.6 sat. sol.
Nitrate of soda,	1.206	0.45	26.4 sat. sol.
Sulphuric acid,	1.840	0.45	
Tartaric acid,	1.285	0.41	53.37 c. acid, sat. sol.
Common salt,	1.212	0.329	29. s. sat. sol.
Muriate of lime,	1.402	0.261	40.2 ignited salt, sat. sol.

Though the influence of the viscidity of a liquid be small with regard to the amount of the absorption, yet it increases the time necessary for the condensation of the gas. In general, the lightest liquids possess the greatest power of absorbing gases; with the exception of those cases where peculiar affinities interfere.

5. Influence of the barometrical pressure on the absorption of gases by liquids.

M. de Saussure shows that in liquids the quantities of gases absorbed are as the compressions; while in solid bodies, on the contrary, as the gases become less dense, the absorption seems to increase. Dr. Henry had previously demonstrated, that the quantity of carbonic acid taken up by water, is proportional to the compressing force; a fact long ago well known and applied by Schweppe, Paul, and other manufacturers of aerated alkaline waters.

6. Simultaneous absorption of several gases by water.

M. de Saussure thinks it probable, that the absorption of the different gases at the same time by liquids, is analogous to what he observed with respect to solid bodies. Henry, Dalton, Van Humboldt, and Gay-Lussac, had already remarked, that water saturated with one gas, allows a portion of that gas to escape, as soon as it comes in contact with another gas. "It is indeed evident, according to Dalton's theory," says M. de Saussure, "that two gases absorbed into a liquid, should really occupy always the same room, as they would occupy, if each of them had been absorbed singly, at the degree of density which it has in the mixture." To obtain results on this subject, approaching to accuracy, he was obliged to make mixtures, of carbonic acid with oxygen, hydrogen, and azotic gases; for the last three gases are absorbed by water, in so small a proportion, that the different condensations which take place, cannot be confounded with errors in the experiments.

1. Water and a mixture of *equal* measures of carbonic acid and hydrogen gas.

He brought 100 measures of water, at the temperature of 62½°, in contact with 434 measures of equal volumes of carbonic acid and hydrogen. The absorption amounted to 47.5 volumes, of which 44 were carbonic acid, and 3.5 hydrogen. If we compare the space which the absorbed gases occupy in the water, with that which they would occupy, according to the preceding table of absorption of unmixed gases, we find that the presence of one of the gases has favoured the absorption of the other, as far as the relative space goes, which each would occupy separately in the water.

2. Water and a mixture of *equal* parts of carbonic acid, and oxygen gas.

100 volumes of water at 62½ degrees absorbed from 390 volumes of this mixture, 52.1 volumes; of which 47.1 volumes were carbonic acid, and 5 volumes oxygen gas. Here also the condensation is greater than when the gases are separate.

3. Water and a mixture of carbonic acid gas and azote.

100 volumes of water absorbed from 357.6 volumes of this mixture, at the above temperature, 47.2 volumes; of which 43.9 volumes were carbonic acid, and 3.3 azote.

The results of these experiments, as we perceive, agree completely with each other; but *none* of them corresponds with Dalton's theory, according to which, the volume of carbonic acid absorbed, should be just one-half of that of the absorbing liquid; and likewise the volumes of the other gases absorbed should be much smaller than M. de Saussure found them actually to be. A mixture of oxygen and hydrogen gases, in the proportions for forming water, by agitation with that liquid, were absorbed in the proportion of 5¼ volumes to 100 volumes of the liquid. In an appendix, M. de Saussure describes minutely the judicious precautions he took to insure precision of result; which leave little doubt of the accuracy of his experiments, and the justness of his conclusions. They are as fatal to Mr. Dalton's mechanical fictions concerning the relation of liquids and gases, as MM. Dulong and Petit's recent researches have been to his geometrical fictions on the phenomena of heat.

III. Of Gaseous Analysis.

This department of chemistry, whose great importance was first shown by Cavendish, Priestley, and Berthollet, has lately acquired new value in consequence of M. Gay-Lussac's doctrine of volumes, his determination of the specific gravities of vapours, and sagacious application of both principles, to the developement of many combinations hitherto intricate and inexplicable.

Let us first take a general view of the characters of the different gases. Some of them are coloured, others diffuse white vapours in the air; some relume a taper, provided a point of its wick remains ignited; others are acid and redden tincture of litmus; one set have no smell, or but a faint one; a second set are very soluble in water; a third are soluble in alkaline solutions; and a fourth are themselves alkaline. Some gases possess several of these characters at once.

1. The *coloured gases* are nitrous acid, chlorine, the protoxide and deutoxide of chlorine. The first is red, the rest yellowish green, or yellowish.

2. Gases producing *white vapours* in the air. Muriatic acid, fluoboric, fluosilicic and hydriodic.

3. Gases *imflammable* in air by contact of the lighted taper. Hydrogen, subcarburetted and carburetted hydrogen, subphosphuretted and phosphuretted hydrogen, sulphuretted hydrogen, arsenuretted hydrogen, telluretted hydrogen, potassuretted hydrogen, carbonous oxide, prussine or cyanogen.

4. Gases which *rekindle* the expiring taper. Oxygen, protoxide of azote, nitrous acid, and the oxides of chlorine.

5. *Acid* gases, which *redden* litmus. Nitrous, sulphurous, muriatic, fluoboric, hydriodic, fluosilicic, chlorocarbonous, and carbonic acids; the oxides of chlorine, sulphuretted hydrogen, telluretted hydrogen, and prussine.

6. Gases *destitute* of *smell*, or possessing but a feeble one. Oxygen, azote, hydrogen, subcarburetted and carburetted hydrogen, carbonic acid, protoxide of azote.

7. The smell of all the others is insupportable, and frequently characteristic.

8. Gases very *soluble in water*, namely, of which water dissolves more than 30 times its volume, at ordinary pressure and temperature. Fluoric acid, muriatic, fluosilicic, nitrous, sulphurous, and ammonia.

9. Gases *soluble* in *alkaline* solutions. Acids, nitrous, sulphurous, muriatic, fluoboric, hydriodic, fluosilicic, chlorine, carbonic, chlorocarbonous; and the two oxides of chlorine, sulphuretted hydrogen, telluretted hydrogen, and ammonia.

10. *Alkaline* gases. Ammonia and potassuretted hydrogen.

Such is a general outline of the characteristics of the gases. *The great problem which now presents itself is, to determine by experiments the nature of any single gas, or gaseous mixture, which may come before us.*

I.

We first fill a little glass tube with it, and expose it to the action of a lighted taper. If it inflames, it is one of the 11 above enumerated, and must be discriminated by the following methods.

1. If it takes fire spontaneously on contact with air, producing a very acid matter, it is *phosphuretted hydrogen.* Subphosphuretted hydrogen, or the bihydroguret of phosphorus, does not spontaneously inflame.

2. If water be capable of decomposing it, and transforming it suddenly into hydrogen gas and alkali, which we can easily ascertain by transferring the test tube filled with it, from the mercurial trough, to a glass containing water, it is *potassuretted hydrogen.* I found in my experiments on the production of potassium, by passing pure potash over ignited iron turnings, of which some account was published in 1809, that potassuretted hydrogen spontaneously inflamed. M. Sementini has made the same observation.

3. If it has a nauseous odour, is insoluble in water, leaves on the sides of the test tube in which we burn it, a chesnut-brown deposite, like hydruret of arsenic, and if, after agitation with the quarter of its volume of aqueous chlorine, a liquid is form-

ed, from which sulphuretted hydrogen precipitates yellow flocculi, it is *arseniuretted hydrogen gas*.

4. If it has a strong smell of garlic or phosphorus, if it does not inflame spontaneously, if the product of its combustion strongly reddens litmus, and if, on agitation with an excess of aqueous chlorine, a liquor results, which, after evaporation, leaves a very sour sirupy residuum, it is *subphosphuretted hydrogen*.

5. If it has no smell or but a faint one, and if it be capable of condensing one-half its volume of oxygen in the explosive eudiometer, it is *hydrogen*.

6. If it has a faint smell, be capable of condensing in the explosive eudiometer one-half of its volume of oxygen, and of producing a volume of carbonic acid equal to its own, which is ascertained by absorbing it with aqueous potash, it is *carbonous oxide*.

7. If it has a faint smell, if one of the products of combustion is carbonic acid, and if the quantity of oxygen, which it condenses by the explosive eudiometer, corresponds to twice or thrice its volume, then it is either *subcarburetted or carburetted hydrogen*.

8. If it diffuses the odour of rotten eggs, if it blackens solutions of lead, if it leaves a deposite of sulphur when we burn it in the test tube, and if it be absorbable by potash, it is *sulphuretted hydrogen*.

9. If it has a fetid odour, approaching to that of sulphuretted hydrogen, if it is absorbable by potash, if it is soluble in water, if it forms with it a liquid, which, on exposure to air, lets fall a brown pulverulent hydruret of tellurium; and lastly, if on agitation with an excess of aqueous chlorine, there results a muriate of tellurium, yielding a white precipitate with alkalis, and a black with the hydrosulphurets, it is *telluretted hydrogen*.

10. *Prussine* is known by its offensive and very peculiar smell, and its burning with a purple flame.

II.

If the gas be non-inflammable, but absorbable by an alkaline solution, it will be one of the 13 following: muriatic acid, fluoboric, fluosilicic, hydriodic, sulphurous, nitrous, chlorocarbonous, carbonic; or chlorine, the oxides of chlorine, prussine, or ammonia. The first four, being the only gases which produce white vapours with atmospheric air, from their strong affinity for water, are thus easily distinguishable from all others. The *fluosilicic gas* is recognized by the separation of silica, in white flocculi, by means of water; and *hydriodic gas*, because chlorine renders it violet, with the precipitation of iodine.

Muriatic acid gas, from its forming with solution of silver a white precipitate insoluble in acids, but very soluble in ammonia, and from its yielding with oxide of manganese a portion of chlorine. *Fluoboric gas*, by the very dense vapours which it exhales, and by its instantly blackening paper plunged into it. *Nitrous acid gas* is distinguished by its red colour. *Protoxide of chlorine*, because it is of a lively greenish-yellow hue, because it exercises no action on mercury at ordinary temperatures, and because, on bringing ignited iron or glass in contact with it, it is decomposed with explosion into oxygen and chlorine.

Deutoxide of chlorine is of a still brighter yellowish-green than the preceding, and has a peculiar aromatic smell. It does not redden, but blanches vegetable blues. At 212° it explodes, evolving oxygen and chlorine. *Chlorine* is distinguished by its fainter yellowish-green colour, by its suffering no change on being heated, by its destroying colours, and by its rapid combination with mercury at common temperatures. *Sulphurous acid* by its smell of burning sulphur. *Ammonia* by its odour, alkaline properties, and the dense white vapours it forms with gaseous acids. *Chlorocarbonous gas* is converted by a very small quantity of water into aqueous muriatic acid, and carbonic acid which rests above. Zinc or antimony, aided by heat, resolves it into carbonous oxide gas, while a solid metallic chloride is formed. With the oxides of the same metals, it forms chlorides, and carbonic acid, while in each case the quantity of gaseous oxide of carbon, and carbonic acid disengaged, is equal to the volume of chlorocarbonous gas operated on. *Carbonic acid gas* is colourless, and void of smell, while all the other gases absorbable by the alkalis have a strong odour. It hardly reddens even very dilute tincture of litmus; it gives a white cloud with lime-water, from which a precipitate falls, soluble with effervescence in vinegar.

III.

If, finally, the gas be neither inflammable nor capable of being absorbed by a solution of potash, it will be oxygen, azote, protoxide of azote, or deutoxide of azote. *Oxygen* can be mistaken only for the protoxide of azote. The property it possesses of rekindling the expiring wick of a taper, distinguishes it from the two other gases. They are moreover characterized, 1st, Because oxygen is void of taste, and capable of condensing in the explosive eudiometer, twice its volume of hydrogen gas; the *protoxide of azote* because it has a sweet taste, is soluble in a little less than half its volume of cold water, and because when detonated with its own volume of hydrogen, we obtain a residuum, containing much azote. The two other gases are distinguished thus: *Deutoxide of azote* is colourless, and when placed in contact with atmospherical air or oxygen, it becomes red, passing to the state of nitrous acid vapour. *Azote* is void of colour, smell, and taste, extinguishes combustibles, experiences no change on contact with air, and produces no cloud with lime-water.

Under the different gases, the reader will find their discriminating characters minutely detailed. We shall conclude this article with a method of solving readily an intricate and common problem in gaseous analysis, for which no *direct* problem has I believe been yet offered. Allusion has been made to it in treating of coal gas, and the plan pointed out in a popular way.

Analytical problem.—In a mixture constituted like purified coal gas, of three inflammable gases, such as olefiant gas, carburetted hydrogen, and carbonous oxide, inseparable by ordinary chemical means, to determine directly the quantity of each.

1. By the rule given at the commencement of the present article *gas*, find from the specific gravity of the mixed gases the proportion of the light carburetted hydrogen. The remainder is the bulk of the other two gases Detonate 100 measures of the mixed gas with excess of oxygen in an explosive eudiometer. Observe the change of volume, and ascertain the expenditure of oxygen. Of the oxygen consumed, allow two volumes for every volume of light carburetted hydrogen, sp. gr. 0.555, previously found, by the hydrostatic rule, to be present. The remaining volumes of oxygen have gone to the combustion of heavy carburetted hydrogen or olefiant gas, and carbonous oxide. Then,

Let $m =$ measure of oxygen equivalent to 1 of first gas,
$n =$ do. do. to 1 of second gas,
$p =$ measures of oxygen actually consumed,
100 or $s =$ volume of mixture of these two gases,
$x =$ volume of first gas,
$s - x =$ volume of second gas.

$$x = \frac{p - ns}{m - n}.$$

Examples.

1*st*. 100 measures of purified coal gas, were found, by the hydrostatic problem, to contain 76 of subcarburetted hydrogen; and exploded in the eudiometer, they were found to consume 187 cubic inches of oxygen. By condensing with potash the carbonic acid formed, we learn the volume of residuary oxygen. But the solution of the problem is otherwise independent of the quantity of carbonic acid, generated in the present experiment. We see from the table of the gases, that 1 volume of olefiant gas is equivalent to 3 of oxygen; and 1 volume carbonous oxide, to one-half volume oxygen. Therefore, deducting for the 76 of subcarbonate, 152 measures of oxygen, the remaining 35 have gone to the 24 measures of the two denser gases. Hence

$$\text{Olefiant gas, or } x = 35\frac{(0.5 \times 24)}{2.5} = 9.2,$$

And $24 - 9.2 = 24.8.$ = the carbonous oxide.

2*d*, 100 measures of a mixture of olefiant gas, and carbonous oxide, take 236 of oxygen: What is the proportion of olefiant gas?

$$x \text{ or olefiant} = 236 - \frac{(0.5 \times 100)}{2.5} = 74.4,$$

consequently 25.6 are carbonous oxide.

This problem is applicable to every mixture of two inflammable gases. The hydrostatic problem I have been accustomed for years to apply to mixtures of two gases, whose specific gravities are considerably different, as carbonic acid and atmospheric air; and with a delicate balance, and globe containing 100 cubic inches, it gives a good accordance with Chemical experiment.

I employed this method for verification, examining the air extracted from the lungs of the criminal's dead body, galvanized at Glasgow in Nov. 1818.

Generally, if we wish to get an approximate knowledge of the proportion of two gases in a mixture, we may adopt the following plan. Poise the exhausted globe or flask at one arm of a delicate balance. Then, connect its stop-cock with the gasometer, bladder, or jar, containing the gaseous mixture. Introduce an unmeasured quantity, great or small, relative to the capacity of the globe; for it is not necessary that the density of the air in the globe should be equal to that of the atmosphere. In fact, it may happen, that the whole quantity of the gaseous mixture may not be equal to more than one-third, one-half, or three-fourths of the capacity of the globe. For instance, in the case of the criminal, I took a globe, capable of receiving greatly more than the aërial contents of his lungs. An unknown quantity of the mixed gases being now in the globe, we suspend it at the balance, and note the increase of weight. We then open the stop-cock, and allow the atmosphere to enter, till an equilibrium of pressure ensues. The additional weight occasioned by the atmospheric air, must be converted into bulk, at the rate of 30.519 gr. for 100 cubic inches. Deducting this bulk from the known capacity of our globe or flask, leaves a remainder, which is the volume of the gaseous mixture first introduced; knowing its weight and volume, we infer its specific gravity; and from its specific gravity, by the hydrostatic problem, we deduce the proportion of each gas in the mixture.

IV. Of the method of determining the specific gravity of gases, and of the modification of their volume from variation of pressure and temperature.—The specific gravity of a gas is the weight of a certain volume of it, compared to the same volume of air or water. Air is now assumed as the standard for gases, as water is for liquids; and the same hydrostatic method is applicable to both elastic and inelastic fluids. We determine the specific gravity of a gas, with an air-pump, balance, and globe or flask, having a stop-cock attached to its orifice. We proceed thus:—We poise the globe at the end of a balance, with its stop-cock open: we next exhaust it, and weigh it in that state. The difference of the two weighings is the apparent weight of the volume of atmospheric air withdrawn from it. We verify that first estimate, by opening the stop-cock, and noting the increase of weight occasioned by the ingress of the air. Having again exhausted, exactly to the same degree, by the mercurial gauge, as before, we poise. This gives us for the third time, the weight of air contained by the globe. The mean of the three trials is to be taken. We now attach it, by the screw of the stop-cock, to a gasometer or jar, containing gas desiccated by muriate of lime over mercury, and opening the communication, allow the air to enter till an equilibrium of pressure with the atmosphere is established. In this stage of the operation, we must avoid grasping the globe with our hands, and we must see that the mercury in the inside and outside of the jar stands truly on a level. On re-suspending the globe at the balance, we find the weight of the included gas, which being divided by the weight of the air formerly determined, gives a quotient, which is the specific gravity of the gas in question. When the utmost precision is required, we should again exhaust the globe, again poise it, and filling it with the gas, again ascertain its sp. gravity under the bulk of the globe. Even a third repetition is sometimes necessary to secure final accuracy. We should always terminate the operations, by a new weighing of the atmospheric air, lest its temperature or pressure may have changed during the course of the experiments. It is obvious, that this method differs in no respect from that practised long ago by the Hon. Robert Boyle, and by Sir Charles Blagden, (See ALCOHOL,) with liquids, and is that which, I suppose, every public teacher of physics, like myself, explains and exhibits annually to his pupils. With regard to liquids, it is necessary to bring them to a standard temperature, which in this country is 60° F. But, as the comparison of gases with air, is always made at the instant, our only care need be, that the gas and atmosphere are in the same state as to temperature and moisture, and that the equilibrium of pressure be insured to the gas, by bringing the liquid which confines it to a level, on the inside and outside of the jar.

If the gases stand over water, it is desirable to weigh them in somewhat cold weather, when the thermometer is, for example, at 40°; for then, the quantity of aqueous vapour they contain is exceedingly small. Or otherwise, we should place the atmospheric air we use for the standard of comparison in the very same circumstances, over water, at 60° for instance; and then with regard to those gases whose density differs little from that of the atmosphere, no correction for vapour need be considered.

From the experiments of M. de Saussure, and those of MM. Clement and Desormes, we learn, that the same bulk of different gases standing over water gives out, on being transmitted over dry muriate of lime, the same quantity of that liquid; which, for 100 cubic inches, is, by the first philosopher, 0.35 of a grain troy at 57° F., and by the second, 0.236 at 54°. We shall, perhaps, not err, by considering the weight to be one-third of a grain at 60°. Now, for 100 cubic inches of hydrogen, which in the dry state weigh only 2.118, one-third of a grain is nearly one-seventh of the whole, equivalent to 14 cubic inches of dry gas. But for oxygen, of which 100 cubic inches weigh nearly 34 grains, one-third of a grain forms only one 110th of the whole.

The quantity of moisture, present in air or gas, at any temperature, may indeed be directly determined from my table of the elasticity of aqueous vapour. If we multiply 19, which is the weight in grains of 100 cubic inches of steam at 212°, by the number 0.516 opposite 60° in my table, we shall have a product, which, divided by 30, will give a quotient, = the weight of aqueous vapour in 100 inches of any gas standing over water at the given temperature. Thus $\frac{19 \times 0.516}{30} = 0.327$, which is very nearly 0.33, as stated above. See *infra*.

The above plan of taking the specific gravity of gases, I believe to be the best, as it was the earliest. Having publicly practised and taught it for 17 years, unconscious of the slightest merit, I was not a little amused at perceiving this old hydrostatic method recently claimed as a *new discovery or invention*.

We have seen, in treating of caloric, that all gaseous matter changes its volume by one 480th part, for the variation of 1° of Fahrenheit's thermometer. This quantity is in decimals = 0.0020833. Hence, if we assume the volume to be equal to unity at 60°, and successively add or subtract that decimal quantity, for every thermometric degree above or below that temperature, we shall have the following table of reduction:—

TABLE of Reduction on Gaseous Volumes, for Variations of Temperature above or below 60°, *by* Dr. URE.

Temp.	Volume.	Temp.	Volume.
60°	1.000000	59°	1.002083
61	0.997916	58	1.004166
62	0.995833	57	1.006249

Temp.	Volume.	Temp.	Volume.
63°	0.993750	56°	1.008333
64	0.991666	55	1.010416
65	0.989583	54	1.012499
66	0.987500	53	1.014583
67	0.985416	52	1.016666
68	0.983333	51	1.018749
69	0.981250	50	1.020833
70	0.979166	49	1.022916
71	0.977083	48	1.024999
72	0.975000	47	1.027083
73	0.972916	46	1.029166
74	0.970833	45	1.031249
75	0.968750	44	1.033333
76	0.966666	43	1.035416
77	0.964583	42	1.037499
78	0.962500	41	1.039583
79	0.960416	40	1.041666
80	0.958333	39	1.043749
81	0.956250	38	1.045833
82	0.954166	37	1.047916
83	0.952083	36	1.049999
84	0.950000	35	1.052083
85	0.947916	34	1.054166
86	0.945833	33	1.056249
87	0.943750	32	1.058333
88	0.941666	31	1.060416
89	0.939583	30	1.062499
90	0.937500	29	1.064583
91	0.935416	28	1.066666
92	0.933333	27	1.068749
93	0.931250	26	1.070833
94	0.929166	25	1.072916
95	0.927083	24	1.074999
96	0.925000	23	1.077083
97	0.922916	22	1.079166
98	0.920833	21	1.081249
99	0.918750	20	1.083333
100	0.916666		

Use of the above Table.

Opposite the temperature of the gas, we find a number, which being multiplied into the volume of the gas, however expressed, gives the true volume at 60°. The table printed in some books, in which unity is placed at 32°, and 1.375 at 212°, can be regarded merely as a specimen of multiplication. In practical chemistry, we seldom think of reducing experimental volumes to the standard of 32° F.

The bulk of a gas being inversely as the pressure, it will necessarily *increase* as the barometer *falls*, and *decrease* as it rises. Hence, to reduce the volume of a gas at any pressure, to what it would be under the mean pressure of 30 inches of mercury; multiply the volume by the particular barometrical pressure, and divide the product by 30; the quotient is the true volume. If the gas be contained in a vessel over mercury, so that the liquid metal stands in the inside of the tube higher than on the outside, it is evident that the gas will be compressed by a less weight than the ambient atmosphere, in proportion to the difference of the mercurial levels. If that difference were 10 inches, then one-third of the incumbent pressure would be counterbalanced, and the gas would become bulkier by one-third. Hence, we must subtract this difference of mercurial levels, from the barometric altitude at the instant, and use this reduced number or remainder, as the proper multiplier in the above rule. Instead of reducing the volume of a gas to what it would be under a mean pressure of 30 inches, it is often desirable to reduce it to another barometrical height, which existed perhaps at the commencement of the experimental investigation. Thus, in applying the eudiometer by slow combustion of phosphorus, we must wait for 24 hours, till the experiment be finished. But in that period, and in our fickle climate, the mercury of the barometer may have moved an inch or more. The general principle, that the volume is inversely as the pressure, measured by the length of the mercurial column, affords the following simple rule:—Multiply the bulk of the gas by the existing height of the barometer, and divide the product by the original height, the quotient is its bulk as at the commencement of the experiment. The barometric pressure is estimated by the inches on its scale, minus the difference of mercurial levels in the pneumatic apparatus. By bringing the two surfaces to one horizontal plane, this correction vanishes. The facility of doing so with my eudiometer, is one of its chief advantages.

If we are operating in the water pneumatic cistern, we can in general bring the two surfaces to a level. If not, we must allow one inch of mercurial pressure for 13.6 inches of water; and, of course, 1-10th of a barometical inch, for every inch and third of water.

M. Gay-Lussac contrived a very ingenious apparatus, to determine the change of volume, which an absolutely dry gas undergoes, when water is admitted to it, in minutely successive portions, till it (or the space it occupies) becomes saturated. He deduced from these accurate experiments, the following formula, whose results coincide perfectly with those deducible from Mr. Dalton's and my experiments on the elastic force of aqueous vapour.

When a perfectly dry gas is admitted to moisture, its volume, v, augments, and becomes $\frac{vp}{p-f}$; in which p = the barometric altitude, in inches, and f = the elastic force of steam at the given temperature. Hence, 100 cubic inches of dry air, weighing 30.519 grains, become 101.75, when transferred over water at 60°. Therefore, 100 cubic inches of such aeriform matter, standing in a jar on the hydro-pneumatic trough, must consist of,

98.28 cubic inches dry air = 29.99 gr.
1.72 aqueous vapour = 0.327gr.

Weight of 100 cubic inches of air, over water at 60° = 30.317 gr.
For hydrogen we shall have,
98.28 inches dry gas - = 2.08157
1.72 aqueous vapour = 0.32680

Weight of 100 cu. in. moist gas = 2.40837
Hence its sp. gr. compared to that of dry air, will be $= \frac{2.40837}{30.519} = 0.07891$, and compared to moist air $= \frac{2.40837}{30.317} = 0.07944$.

For chlorine we shall have (making the sp. gr. of the dry gas = 2.5),
98.28 cubic inches - = 74.9857
1.72 aqueous vapour - = 0.3268

Weight of 100 cu. in. of moist chl. = 75.3125
Hence, its sp. gr. compared to that of dry air, will be $= \frac{75.3125}{30.519} = 2.4677$, and compared to moist air $= \frac{75.3125}{30.317} = 2.48416$.

Now, the first is almost the density assigned long ago by M.M. Gay-Lussac and Thenard; on which, if we make the correction for aqueous vapour present in it, on account of this gas never being collected over mercury, we shall have its true specific grav. = 2.5. Sir H. Davy brought out a number still nearer 2.5, than that of M. Gay-Lussac. His chlorine was probably compared with air somewhat moist, and may therefore be considered as readily reducible, by a minute correction, to 2.5. The reason assigned by Dr. Thomson (Annals for Sept. and Oct. 1820,) for the former erroneous estimates of the sp. gravity of that gas, cannot surely apply to the two first chemists of the age; namely, that the chlorine they prepared as the standard of comparison, was impure. I think the true reason is that, which I have now given.

For olefiant and carbonic oxide gases, we shall have,
98.28 cubic inches - = 29.1564
1.72 vapour - - = 0.3268

Weight of 100 cub. in. of moist gas = 29.4832
Hence, its sp. gr. compared to that of dry air, will be $= \frac{29.4832}{30.519} = 0.966$, and to moist air $= \frac{29.4832}{30.317} = 0.9725$.

Dr. Thomson appears to have collected his chlorine, olefiant gas, and carbonic oxide, over water. Hence, his late results on them, if at 60° F. are erroneous; and instead of confirming the theoretical numbers deducible from Higgins's atomic doctrine, and M. Gay-Lussac's theory of volumes, they are inconsistent with both. One might suppose that he had prepared his apparatus for measuring gaseous specific gravity, in the workshop of Procrustes. But far be it from me, to retort on him, the insinuation which he throws out against M. Thenard in his system of Chemistry, vol. iv. p. 385: "This result approaches so nearly that of Lavoisier (Prout), that there is reason to suspect that the coincidence is more than accidental." In fact, Dr. Thomson's present experiments in the above case, would prove a great deal too much. Every result indeed which he sets down in the above two journals, is logically deducible from pre-existing facts, and in my apprehension, does not add an iota to the strength of their former evidence. There are many niceties to be observed, before we can obtain, by *experiment*, the exact densities of gaseous matter. On this subject the reader may consult, with much advantage, Biot's *Traité de Physique*, vol. 1st, where geometry and experiment go hand and hand, notwithstanding Dr. Thomson's condemnation of it, in the following words: "Indeed, to be convinced of the little utility of mere mathematical formulas, towards promoting this science without the aid of experiment, the reader has only to peruse the chemical part of Biot's *Traité de Physique*, where he will find abundance of specimens of most elaborate mathematical investigations, which leave every subject precisely in the state in which they found it." Annals of Phil. for Sept. 1820. Let me recommend to the doctor, Biot's chapter on the sp. gr. of gases, and not to vilify a book, by the unacknowledged aid of which, he has given an air of original research to his article DECOMPOSITION, in the Supplement to the Enc. Brit. 5th edit.*

GASTRIC JUICE is separated by glands placed between the membranes which line the stomach; and from these it is emitted into the stomach itself.

From various experiments it follows:

1. That the gastric juice reduces the aliments into a uniform magma, even out of the body, and in vitro; and that it acts in the same manner on the stomach after death; which proves that its effect is chemical, and almost independent of vitality. 2. That the gastric juice effects the solution of the aliments included in tubes of metal, and consequently defended from any trituration. 3. That though there is no trituration in membranous stomachs, this action powerfully assists the effect of the digestive juices in animals with a muscular stomach, such as ducks, geese, pigeons, &c. Some of these animals, bred up with sufficient care that they might not swallow stones, have nevertheless broken spheres and tubes of metal, blunted lancets, and rounded pieces of glass; which were introduced into their stomachs. Spallanzani has ascertained, that flesh, included in spheres sufficiently strong to resist the muscular action, was completely digested. 4. That gastric juice acts by its solvent power, and

not as a ferment; because the ordinary and natural digestion is attended with no disengagement of air, or inflation, or heat, or, in a word, with any other of the phenomena of fermentation.

* **Gehlenite.** A mineral substance allied to Vesuvian. Its colours are olive-green, leek-green, green of other shades, and brown. It occurs crystallized in rectangular four-sided prisms, which are so short as to appear tables. Lustre glistening, often dull. Cleavage imperfect, but three-fold rectangular. Fracture fine splintery. Translucent on the edges. Rather easily frangible. Harder than feldspar, but softer than quartz. Sp. gr. 2. 98. It melts before the blow-pipe into a brownish-yellow transparent glass. It is found along with calcareous spar in the valley of Fassa in the Tyrol. Its constituents are, lime 35.5, silica 29.64, alumina 24.8, oxide of iron 6.56, volatile matter 3.3.*

Gelatin, Gelly, or **Jelly,** an animal substance, soluble in water, capable of assuming a well-known elastic or tremulous consistence by cooling, when the water is not too abundant, and liquefiable again by increasing its temperature. This last property distinguishes it from albumen, which becomes consistent by heat. It is precipitated in an insoluble form by tannin, and it is this action of tannin on gelatin that is the foundation of the art of tanning leather. See **Glue.**

*According to the analysis of MM. Gay-Lussac and Thenard gelatin is composed of

Carbon,	-	47 881
Oxygen,	-	27.207
Hydrogen,	-	7.914
Azote, -	-	16.998
		100.000*

Gems. This word is used to denote such stones as are considered by mankind as precious. These are the diamond, the ruby, the sapphire, the topaz, the chrysolite, the beryl, the emerald, the hyacinth, the amethyst, the garnet, the tourmalin, the opal; and to these may be added, rock crystal, the finer flints of pebbles, the cat's eye, the oculus mundi, or hydrophanes, the chalcedony, the moon-stone, the onyx, the carnelian, the sardonyx, agates, and the Labrador-stone; for which, consult the several articles respectively.

Geodes. A kind of ætites, the hollow of which, instead of a nodule, contains only loose earth, and is commonly lined with crystals:

* **Geognosy.** See **Geology.***

* **Geology.** A description of the structure of the earth. This study may be divided, like most others, into two parts; observation and theory. By the first we learn the relative positions of the great rocky or mineral aggregates that compose the crust of our globe; through the second, we endeavour to penetrate into the causes of these collocations. A valuable work has been lately published, comprehending a view of both parts of the subject, by Mr. Greenough, to which I refer my readers for much instruction, communicated in a very interesting manner. The plan of this work permits me merely to give in this place an outline of the general arrangement of the great mineral masses, as ascertained by Werner, and described by Professor Jameson.

There is a great class of rocks, which lies under every other, but never over any of them; it is therefore reckoned by Werner the oldest or first formed. It is denominated the *primitive* class. The rocks belonging to this class, have a crystalline appearance, indicating that they have been precipitated from a state of chemical solution. They are principally composed of siliceous, argillaceous, and magnesian earths. Granite, gneiss, mica-slate, clay-slate, serpentine, porphyry, and syenite, are of this kind. Of these, granite is the oldest, and syenite is the newest.

To this succeeds another considerable class of rocks, which Werner denominates *transition*. In this class, which is principally composed of chemical productions, mechanical depositions first make their appearance, but in the earlier part, in inconsiderable quantity.

Limestone first occurs in considerable quantity in this class.

Graywacke, graywacke slate, and transition limestone, are the predominating rocks of this class.

Still newer, and consequently lower, than the transition class, is the extensive class of floetz rocks. Here mechanical deposites occur in great quantity, and the proportion of chemical precipitate decreases. The principal rocks are limestone and sandstone; to these may be added gypsum, salt, and great accumulations of inflammable matter in the state of coal.

Still newer and lower is the class of alluvial rocks, which are almost entirely composed of mechanical deposites. Sand, clay, loam, and coal, are the principal earthy masses that belong to this class.

The newest of all, is the class of volcanic rocks. Different kinds of *lava* and *tuff* include nearly all the variety of rocks belonging to this class.

In the first class, we observe several rocks always disposed in conformable and unbroken stratification, and in which the newer and newer strata, have always a lower and lower level. Gneiss, mica-slate, and clay-slate, are of this kind. The granite stretches under them uninterruptedly, and sometimes rises up through them, or juts up in the form of single caps or great masses; so that the gneiss, and other rocks, are disposed on its surface, sometimes in a concave, sometimes in a convex direction; sometimes saddle-shaped, and frequently mantle-shaped. It is evident, from the relations of the strata, that granite will frequently form the greatest heights on the surface of the globe.

Porphyry has a very different kind of stratification from the preceding rocks. It occurs sometimes broken, sometimes unbroken. When broken, it presents caps, upfillings, and shield-shaped stratifications. When unbroken, it forms widely extended masses. Its position is *unconformable and overlying*.

Graywacke occurs sometimes in an unconformable position; also in caps, upfillings, and shield-shaped, and frequently mantle-shaped strata, surrounding the older mountains.

The limestone and sandstone formations are usually disposed in a mantle-shape around the older formations; sometimes they are broken, but more frequently unbroken. They are very common and widely distributed formations.

Coal again shows a very peculiar character. Its original extent is not considerable; it even appears interrupted and broken; but its internal characters show that its present apparently broken appearance is its original one. It occurs commonly in trough and basin-shaped hollows, and its strata have consequently a concave direction.

The rocks of the *newest floetz-trap formation* are distinguished from the older by their unconformable overlying, and broken stratification. In these respects, they nearly agree with porphyry. When the continuity of the formation is broken, it occurs in caps, upfillings, and rarely shield-shaped.

Table of the different Mountain Rocks.

Class I.
Primitive rocks.

1. Granite.
2 Gneiss.
3. Mica-slate.
4. Clay-slate.
5. Primitive limestone.
6. Primitive trap.
7. Serpentine.
8. Porphyry.
9. Syenite.
10. Topaz-rock.
11. Quartz-rock.
12. Primitive flinty-slate.
13. Primitive gypsum.

*

14 White-stone.

Class II.
Transition rocks.

1. Transition limestone.
2. Transition trap.
3. Graywacke.
4. Transition flinty-slate.
5. Transition gypsum.

Class III.
Floetz rocks.

1. Old red sandstone, or first sandstone formation.
2. First or oldest floetz limestone.
3. First or oldest floetz gypsum.
4. Second or variegated sandstone formation.
5. Second floetz gypsum.
6. Second floetz limestone.
7. Third floetz limestone.
8. Rock-salt formation.
9. Chalk formation.
10. Floetz-trap formation.
11. Independent coal formation.
12. Newest floetz-trap formation.

Class IV.
Alluvial rocks.

1. Peat.
2. Sand and gravel.
3. Loam.
4. Bog-iron ore.
5. Nagelfluh.
6. Calc-tuff.
7. Calc-sinter.

Class V.
Volcanic rocks.

* Pseudo-volcanic rocks.

1. Burnt clay.
2. Porcelain jasper.
3. Earth slag.
4. Columnar clay ironstone.
5. Polier, or polishing slate.

** *True volcanic rocks.*

1. Ejected stones and ashes.
2. Different kinds of lava.
3. The matter of muddy eruptions.

Professor Jameson has lately announced a new volume on geology, which will most probably exhibit some modification of the above arrangements, to which Mr. Greenough, and other accurate practical geologists, have made several objections.

The ancient history of the globe, which may be regarded as the *ultimate* object of geological researches, is undoubtedly one of the most curious subjects that can engage the attention of enlightened men. The lowest and most level parts of the earth, when penetrated to a very great depth, exhibit nothing but horizontal strata, composed of various substances, and containing almost all of them innumerable marine productions. Similar strata, with the same kind of productions, compose the hills even to a great height. Sometimes the shells are so numerous as to constitute the entire body of the stratum. They are almost every-where in such a perfect state of preservation, that even the smallest of them retain their most delicate parts, their sharpest ridges, and tenderest processes. They are found in elevations far above the level of every part of the ocean, and in places to which the sea could not be conveyed by any presently existing cause. They are not merely enclosed in loose sand, but are often increased and penetrated on all sides by the hardest stones. Every part of the earth, every hemisphere, every continent, every island of any size, exhibits the same phenomenon. We are therefore forcibly led to believe, not only that the sea has at one period or another covered all our plains, but that it must have remained there for a long time, and in a state of tranquility; which circumstance was necessary for the formation of deposites so extensive, so thick, in part so solid, and containing exuviæ so perfectly preserved. A nice and scrupulous comparison of the forms, contexture, and composition of these shells, and of those which still inhabit the sea, cannot detect the slightest difference between them. They have therefore once lived in the sea, and been deposited by it; the sea consequently must have rested in the places where the deposition has taken place. Hence it is evident, that the basin or reservoir containing the sea has undergone some change, either in extent, situation, or both.

The traces of revolutions become still more apparent and decisive, when we ascend a little higher, and approach nearer to the foot of the great chain of mountains. There are still found many beds of shells; some of these are even larger and more solid; the shells are quite as numerous, and as entirely preserved; but they are not of the same species with those which were found in the less elevated regions. The strata which contain them are not so generally horizontal; they have various degrees of inclination, and are sometimes situated vertically. While in the plains and low hills it was necessary to dig deep in order to detect the succession of the strata; here we perceive them by means of the valleys, which time or violence has produced, and which disclose their edges to the eye of the observer.

Thus the sea, previous to the formation of the horizontal strata, had formed others, which by some means have been broken, lifted up, and overturned in a thousand ways. But the sea has not always deposited stony substances of the same kind. It has observed a regular succession as to the nature of its deposites; the more ancient the strata are, so much the more uniform and extensive are they; and the more recent they are, the more limited are they, and the more variation is observed in them at small distances. Thus the great catastrophes which have produced revolutions in the basins of the sea, were preceded, accompanied, and followed by changes in the nature of the fluid, and of the substances which it held in solution; and when the surface of the seas came to be divided by islands and projecting ridges, different changes took place in every separate basin.

These irruptions and retreats of the sea have neither been slow nor gradual; most of the catastrophes which have occasioned them have been sudden; and this is easily proved, especially with regard to the last of them, or the Mosaic deluge, the traces of which are very conspicuous. In the northern regions it has left the carcases of some large quadrupeds, which the ice had arrested, and which are preserved even to the present day, with their skin, their hair, and their flesh. If they had not been frozen as soon as killed, they must have been quickly decomposed by putrefaction. But this perpetual frost could not have taken possession of the regions which these animals inhabited, except by the same cause which destroyed them; this cause must therefore have been as sudden as its effect. The two most remarkable phenomena of this kind, and which must for ever banish all idea of a slow and gradual revolution, are the rhinoceros, discovered in 1771 on the banks of the *Vilhoui*, and the elephant, recently found by M. Adams near the mouth of the *Sena*. This last retained its flesh and skin, on which was hair of two kinds; one short, fine, and crisped, resembling wool; and the other like bristles. The flesh was still in such high preservation, that it was eaten by dogs. Every part of the globe bears the impress of these great and terrible events so distinctly, that they must be visible to all who are qualified to read their history in the remains which they have left behind.—*See Cuvier's Theory of the Earth.*

I shall conclude this article by stating, that this naturalist, the most learned of the present day, as well as Dolomieu, Deluc, and Greenough, concur in thinking that not above 5000 or 6000 years have elapsed since the period of the deluge, which agrees with the Mosaic epoch of that catastrophe.*

* **Germination.** The vital developement of a seed, when it first begins to grow.*

Gilding. The art of covering the surfaces of bodies with gold.

The gold prepared for painting is called shell-gold or gold-powder, and may be obtained by amalgamating one part of gold with eight of quicksilver, and afterward evaporating the latter, which leaves the gold in the form of powder; or otherwise the metal may be reduced to powder by mechanical trituration. For this purpose, gold leaf must be ground with honey or strong gum-water for a long time; and when the powder is sufficiently fine, the honey or gum may be washed off with water.

For cold gilding by friction, a fine linen rag is steeped in a saturated solution of gold till it has entirely imbibed the liquor; this rag is then dried over a fire, and afterward burned to tinder. Now, when any thing is to be gilded, it must be previously well burnished; a piece of cork is then to be dipped, first into a solution of salt in water, and afterward into the black powder; and the piece, after it is burnished, rubbed with it.

For water gilding, the solution of gold may be evaporated till it is of an oily consistence, suffered to crystallize, and the crystals dissolved in water be employed instead of the acid solution. If this be copiously diluted with alcohol, a piece of clean iron will be gilded by being steeped therein. Or add to the solution about three times its quantity of sulphuric ether, which will soon take up the nitro-muriate of gold, leaving the acid colourless at the bottom of the vessel, which must then be drawn off. Steel dipped into the ethereal solution for a moment, and instantly washed in clean water, will be completely and beautifully covered with gold. The surface of the steel must be well polished, and wiped very clean.

For the method called Grecian gilding, equal parts of sal ammoniac and corrosive sublimate are dissolved in nitric acid, and a solution of gold is made in this menstruum; upon this the solution is somewhat concentrated, and applied to the surface of silver, which becomes quite black; but on being exposed to a red heat, it assumes the appearance of gilding.

The method of gilding silver, brass, or copper, by an amalgam, is as follows: Eight parts of mercury, and one of gold, are incorporated together by heating them in a crucible. As soon as the gold is perfectly dissolved, the mixture is poured into cold water, and is then ready for use.

Before the amalgam can be laid upon the surface of the metal, this last is brushed over with dilute aquafortis, in which it is of advantage that some mercury may have been dissolved. Some artists then wash the metal in fair water, and scour it a little with fine sand, previous to the application of the gold; but others apply it to the metal while still wet with the aquafortis. But in either case the amalgam must be laid on as uniformly as possible, and spread very evenly with a brass-wire brush, wetted from time to time with fair water. The piece is then laid upon a grate, over a charcoal fire, or in a small oven or furnace adapted to this purpose. The heat drives off the mercury, and leaves the gold behind. Its defects are then seen, and may be remedied by successive applications of more amalgam, and additional application of heat. The expert artists however, make these additional applications while the piece remains in the furnace, though the practice is said to be highly noxious on account of the mercurial fumes. After this it is rubbed with gilder's wax, which may consist of four ounces of bees' wax, one ounce of verdigris, and one ounce of sulphate of copper; then expose it to a red heat, which burns off the wax; and, lastly, the work is cleared with the scratch brush, and burnished, if necessary, with a steel tool. The use of the wax seems to consist merely in covering defects, by the diffusion of a quantity of red oxide of copper, which is left behind after the burning.

The gilding of iron by mere heat is performed by cleaning and polishing its surface, and then heating it till it has acquired a blue colour. When this has been done, the first layer of gold leaf is put on, slightly burnished down, and exposed to a gentle fire. It is usual to give three such layers, or four at the most, each consisting of a single leaf for common works, or two for extraordinary ones. The heating is repeated at each layer, and last of all the work is burnished.

The gilding of buttons is done in the following way: When the buttons, which are of copper, are made, they are dipped into dilute nitric acid to clean them, and then burnished with a hard black stone. They are then put into a nitric solution of mercury, and stirred about with a brush, till they are quite white. An amalgam of gold and mercury is then put into an earthen vessel with a small quantity of dilute nitric acid, and in this mixture the buttons are stirred, till the gold attaches to their surface. They are then heated over the fire, till the mercury begins to run, when they are thrown into a large cap made of coarse wool and goat's hair, and in this they are stirred about with a brush. The mercury is then volatilized by heating over the fire in a pan, to the loss of the article, and injury of the workmen's health; though the greater part might be recovered, with less injury to the operators. By act of parliament, a gross of buttons, of an inch diameter, are required to have five grains of gold on them; but many are deficient even of this small quantity.

Painting with gold upon porcelain or glass is done with the powder of gold, which remains behind after distilling, the aqua regia from a solution of that metal. It is laid on with borax and gum-water, burned in, and polished. The gilding of glass is commonly effected by covering the part with a solution of borax, and applying gold leaf upon it, which is afterwards fixed by burning.

Gilding in oil is performed by means of a paint sold under the name of gold size. It consists of drying oil, (that is to say, linseed oil boiled upon litharge), and mixed with yellow ochre. It is said to improve in its quality by keeping. This is laid upon the work; and when it has become so dry as to adhere to the fingers without soiling them, the gold leaf is laid on, and pressed down with cotton. This method of gilding is proper for work intended to be exposed to the weather.

The method of gilding in burnished gold consists in covering the work with parchment size and whiting, thinly laid on at five or six different times. This is covered with a yellow size made of Armenian bole, a little wax, and some parchment size; but in this, as in most other compositions used in the arts, there are variations which depend on the skill or the caprice of the artists. When the size is dry, the gold is applied upon the surface previously wetted with clear water. A certain number of hours after this application, but previous to the perfect hardening of the composition, the gold may be very highly burnished with a tool of agate made for this purpose. This gilding is fit only for work within doors; for it readily comes off upon being wetted.

The edges of the leaves of books are gilded by applying a composition of one part Armenian bole, and one quarter of a part of sugar-candy, ground together with white of eggs. This is burnished while the book remains in the press, and the gold is laid on by means of a little water.

Leather is gilded either with leaf-brass or silver, but most commonly by the latter, in which case a gold coloured varnish is laid over the metal. Tin-foil may be used instead of silver leaf for this less perfect gilding upon such works as do not possess flexibility.

* GLASS. Most of the treatises, which I have seen on the manufacture of glass, illustrate a well known position, that it is easy to write a large volume, which shall communicate no definite information. There are five distinct kinds of glass at present manufactured:—

1. Flint glass, or glass of lead.
2. Plate glass, or glass of pure soda.
3. Crown glass, the best window-glass.
4. Broad glass, a coarse window-glass.
5. Bottle, or coarse green glass.

1. *Flint Glass*, so named because the siliceous ingredient was originally employed in the form of ground flints. It is now made of the following composition:—

Purified Lynn sand,	100 parts
Litharge or red lead,	60
Purified pearl ash,	30

To correct the green colour derived from combustible matter, or oxide of iron, a little black oxide of manganese is added, and sometimes nitre and arsenic. The fusion is accomplished usually in about thirty hours.

2. *Plate Glass*. Good carbonate of soda procured by decomposing common salt with pearl ash, is employed as the flux. The proportion of the materials is,

Pure sand, - - - - - -	43.0
Dry subcarbonate of soda, -	26.5
Pure quicklime, - - - -	4.
Nitre, - - - - - - - - -	1.5
Broken plate glass, - - -	25.0
	100.0

About seventy parts of good plate glass may be run off from these materials.

3. *Crown, or fine Window-glass*. This is made of sand vitrified by the impure barilla, manufactured by incineration of seaweed, on the Scotch and Irish shores. The most improved composition, is

	By measure.	*By weight.*
Fine sand purified,	5	200
Best kelp ground,	11	330

These ingredients are mixed, and then thrown into the fritting arch, where the sulphur of the kelp is dissipated, and the matters are thoroughly incorporated, forming, when withdrawn at the end of four hours, a grayish-white tough mass, which is cut into brick-shaped pieces, and after concretion and cooling, piled up for use. By long keeping, a soda efflorescence forms on their surface. They are then supposed to have become more valuable. These bricks are put into the melting pots, and sometimes a proportion of common salt is thrown in towards the end of the operation, if the vitrification has been imperfect. Under the article *sulphate of soda*, in this Dictionary, retained from the old edition, there is the following sentence: "Pajot des Charmes has made some experiments on it in fabricating glass; with sand alone, it would not succeed, but equal parts of carbonate of lime, sand, and dried sulphate of soda, produced a clear, solid, pale-yellow glass." In the Annals of Philosophy for Jan. 1817, we find the following notice from Schweigger's Journal, xv. 89.: Gehlen, some time before his death, was occupied with experiments on the preparation of glass, by means of sulphate of soda. Professor Schweigger has lately published the result of his trials. He found that the following proportions were the best:—

Sand, - - - - -	100
Dry sulphate of soda, -	50
Dry quicklime in powder,	17 to 20
Charcoal, - - - -	4

This mixture always gives a very good glass without any addition whatever. During the fusion, the sulphuric acid is decomposed and drawn off, and the soda unites with the silica. The sulphate of soda vitrifies very imperfectly, when mixed alone with the silica. The vitrification succeeds better when quicklime is added, and it succeeds completely, when the proportion of charcoal in the formula is added; because the sulphuric acid is thereby decomposed and dissipated. This decomposition may be either effected during the making of the glass, or before, at the pleasure of the workmen.

4. *Broad Glass.* This is made of a mixture of soap boilers' waste, kelp, and sand. The first ingredient consists of lime used for rendering the alkali of the soap boiler caustic, the insoluble matter of his kelp or barilla, and a quantity of salt and water, all in a pasty state. The proportions necessarily vary. 2 of the waste, 1 of kelp, and 1 of sand, form a pretty good broad glass. They are mixed together, dried, and fritted.

5. *Bottle Glass* is the coarsest kind. It is made of soaper's waste and river sand, in proportions which practice must determine according to the qualtity of the waste; some soap boilers extracting more saline matter, and others less from their kelps. Common sand and lime, with a little common clay and sea salt, form a cheap mixture for bottle glass.*

As far as observation has hitherto directed us, it appears to be a general rule, that the hardness, brittleness, elasticity, and other mechanical properties of congealed bodies, are greatly affected by the degree of rapidity with which they assume the solid state. This, which no doubt is referable to the property of crystallisation, and its various modes, is remarkably seen in steel and other metals, and seems to obtain in glass. When a drop of glass is suffered to fall into water, it is found to possess the remarkable property of flying into minute pieces, the instant a small part of the tail is broken off. This, which is commonly distinguished by the name of Prince Rupert's drop, is similar to the philosophical phial; which is a small vessel of thick glass suddenly cooled by exposure to the air. Such a vessel possesses the property of flying in pieces, when the smallest piece of flint or angular pebble is let fall into it, though a leaden bullet may be dropped into it from some height without injury. Many explanations have been offered, to account for these and other similar appearances, by referring to a supposed mechanism or arrangement of the particles, or sudden confinement of the matter of heat. The immediate cause, however, appears to be derived from the fact, that the dimensions of bodies suddenly cooled remain larger, than if the refrigeration had been more gradual. Thus the specific gravity of steel hardened by sudden cooling in water is less, and its dimensions consequently greater than that of the same steel gradually cooled. It is more than probable, that an effect of the same nature obtains in glass; so that the dimensions of the external and suddenly cooled surface remain larger than are suited to the accurate envelopement of the interior part, which is more slowly cooled. In most of the metals, the degree of flexibility they possess, must be sufficient to remedy this inaccuracy as it takes place; but in glass, which, though very elastic and flexible, is likewise excessively brittle, the adaptation of the parts, urged different ways by their disposition to retain their respective dimensions and likewise to remain in contact, by virtue of the cohesive attraction, can be maintained only by an elastic yielding of the whole, as far as may be, which will therefore remain in a state of tension. It is not therefore to be wondered at, that a solution of continuity of any part of the surface should destroy this equilibrium of elasticity; and that the sudden action of all the parts at once, of so brittle a material, should destroy the continuity of the whole, instead of producing an equilibrium of any other kind.

Though the facts relating to this disposition of glass too suddenly cooled, are numerous and interesting to the philosopher, yet they constitute a serious evil with respect to the uses of this excellent material. The remedy of the glass-maker consists in annealing the several articles, which is done by placing them in a furnace, near the furnace of fusion. The glasses are first put into the hottest part of this furnace, and gradually removed to the cooler parts at regular intervals of time. By this means the glass cools very slowly throughout, and is in a great measure free from the defects of glass which has been too hastily cooled.

M. Reaumur was the first who made any direct experiments upon the conversion of glass into porcelain. Instances of this effect may be observed among the rubbish of brick-kilns, where pieces of green bottles are not unfrequently subjected by accident, to the requisite heat; but the direct process is as follows: A vessel of green glass is to be filled up to the top with a mixture of white sand and gypsum, and then set in a large crucible upon a quantity of the same mixture, with which the glass vessel must also be surrounded and covered over, and the whole pressed down rather hard. The crucible is then to be covered with a lid, the junctures well luted, and put into a potter's kiln, where it must remain during the whole time that the pottery is baking; after which, the glass vessel will be found transformed into a milk-white porcelain. The glass, on fracture, appears fibrous, as if it were composed merely of silken threads laid by the side of each other: it has also quite lost the smooth and shining appearance of glass, is very hard, and emits sparks of fire when struck with steel; though not so briskly as real porcelain. Lewis observed, that the above-mentioned materials have not exclusively this effect upon glass; but that powdered charcoal, soot, tobacco-pipe clay, and bone-ashes, produce the same change. It is remarkable, that the surrounding sand becomes in some measure agglutinated by this process, which, if continued for a sufficient length of time, entirely destroys the texture of the glass, and renders it pulverulent.

The ancient stained glass has been much admired, and beautiful paintings on this substance have been produced of late years. The colours are of the nature of those used in enamelling, and the glass should have no lead in its composition. Mr. Brongniart has made many experiments on this subject. The purple of Cassius, mixed with six parts of a flux, composed of borax, and glass made with silex and lead, produces a very beautiful violet, but liable to turn blue. Red oxide of iron, prepared by means of the nitric acid and subsequent exposure to fire, and mixed with a flux of borax, sand, and a small portion of minium, produces a fine red. Muriate of silver, oxide of zinc, white clay, and the yellow oxide of iron, mixed together without any flux, produce a yellow, light or deep, according to the quantity laid on, and equal in beauty to that of the ancients. A powder remains on the surface after baking, which may easily be cleaned off. Blue is produced by oxide of cobalt, with a flux of silex, potash, and lead. To produce a green, blue must be put on one side of the glass, and yellow on the other; or a blue may be mixed with yellow oxide of iron. Black is made by a mixture of blue with the oxides of manganese and iron.

The bending of the glass, and alteration of the colours, in baking, are particularly to be avoided, and require much care. Gypsum has been recommended for their support, but this frequently renders the glass white, and cracked in all directions, probably from the action of the hot sulphuric acid on the alkali in the glass. Mr. Brongniart placed his plates of glass, some of them much larger than any ever before painted, on very smooth plates of earth or porcelain unglazed, which he found to answer extremely well.

* **Glauber Salt.** Native sulphate of soda. Its colours are grayish and yellowish-white. It occurs in mealy efflorescences, prismatic crystals, and imitative shapes. Lustre vitreous. Cleavage threefold. Fracture conchoidal. Soft. Brittle. Sp. gr. 2.2 to 2.3. Taste at first cooling, then saline and bitter. Its solution does not, like that of Epsom salt, afford a precipitate with an alkali. Its constituents are, sulphate of soda 67; carbonate of soda 16⅓; muriate of soda 11; carbonate of lime 5.64. It occurs along with rock salt and Epsom salt, on the borders of salt lakes, and dissolved in the waters of lakes and the ocean; in efflorescences on moorish ground; also on sandstone, marl-slate, and walls. It is found at Eger in Bohemia, on meadow-ground, as an efflorescence, and in galleries of mines in several places.*—*Jameson.*

* **Glauberite.** Colours grayish-white, and wine-yellow. Crystallized in very low oblique four-sided prisms, the lateral edges of which are 104° 28′, and 75° 32′. Lateral planes transversely streaked; terminal planes smooth. Shining. Fracture foliated or conchoidal. Softer than calcareous spar. Transparent. Brittle. Sp. gr. 2.7. It decrepitates before the blowpipe, and melts into white enamel. In water it becomes opaque, and is partly soluble. Its constituents are, dry sulphate of lime 49; dry sulphate of soda 51. It is found imbedded in rock-salt, at Villaruba, near Ocana, in New Castile in Spain.*—*Jameson.*

Glazing. See **Pottery.**

Glimmer. A name occasionally applied to micaceous earths.

* **Gliadine.** See **Gluten.***

Glucina. This earth was discovered by Vauquelin, first in the aqua marina, and afterward in the emerald, in the winter of 1798. Its name is derived from its distinguishing character of forming with acids, salts that are sweet to the taste. The following is his method of obtaining it:—

Let 100 parts of beryl, or emerald, be reduced to a fine powder, and fused in a silver crucible with 300 of pure potash. Let the mass be diffused in water, and dissolved by adding muriatic acid. Evaporate the solution, taking care to stir it toward the end: mix the residuum with a large quantity of water, and filter, to separate the silex. Precipitate the filtered liquor, which contains the muriates of alumina and glucina, with carbonate of potash; wash the precipitate, and dissolve it in sulphuric acid. Add a certain quantity of sulphate of potash, evaporate, and crystals of alum will be obtained. When no more alum is afforded by adding sulphate of potash and evaporating, add solution of carbonate of ammonia in excess, shake the mixture well, and let it stand some hours, till the glucina is redissolved by the excess of carbonate of ammonia, and nothing but the alumina remains at the bottom of the vessel. Filter the solution, evaporate to dryness, and expel the acid from the carbonate of glucina, by slight ignition in a crucible. Thus 15 or 16 per cent of pure glucina will be obtained.

Glucina thus obtained, is a white, soft powder, light, insipid, and adhering to the tongue. It does not change vegetable blues. It does not harden, shrink, or agglutinate by heat; and is infusible. It is insoluble in water, but forms with it a slightly ductile paste. It is dissolved by potash, soda, and carbonate of ammonia; but not by pure ammonia. It unites with sulphuretted hydrogen. Its salts have a saccharine taste, with somewhat of astringency.

* Sir H. Davy's researches have rendered it more than probable, that glucina is a compound of oxygen and a peculiar metallic substance, which may be called *glucinum*. By heating it along with potassium, the latter was converted for the most part into potash, and dark coloured particles, having a metallic appearance, were found diffused through the mass, which regained the earthy character by being heated in the air, and by the action of water. In this last case, hydrogen was slowly disengaged. According to Sir H. Davy, the prime equivalent of glucina would be 3.6 on the oxygen scale, and that of glucinum 2.6. These are very nearly the equivalents of lime, and calcium. From the composition of the sulphate, Berzelius infers the equivalent to be 3.2, and that of its basis 2.2.*

Glue. An inspissated jelly made from the parings of hides and other offals, by boiling them in water, straining through a wicker basket, suffering the impurities to subside, and then boiling it a second time. The articles should first be digested in lime-water, to cleanse them from grease and dirt; then steeped in water, stirring them well from time to time; and lastly, laid in a heap, to have the water pressed out, before they are put into the boiler. Some recommend, that the water should be kept as nearly as possible to a boiling heat, without suffering it to enter into ebullition. In this state it is poured into flat frames or moulds, then cut into square pieces when congealed, and afterward dried in a coarse net. It is said to improve by age; and that glue is reckoned the best, which swells considerably without dissolving by three or four days infusion in cold water, and recovers its former dimensions and properties by drying.

Shreds or parings of vellum, parchment, or white leather, make a clear and almost colourless glue.

Gluten (Vegetable). If wheat-flour be made into a paste, and washed in a large quantity of water, it is separated into three distinct substances; a mucilaginous saccharine matter, which is readily dissolved in the liquor, and may be separated from it by evaporation; starch, which is suspended in the fluid, and subsides to the bottom by repose; and gluten, which remains in the hand, and is tenacious, very ductile, somewhat elastic, and of a brown-gray colour. The first of these substances does not essentially differ from other saccharine mucilages. The second, namely, the starch, forms a gluey fluid by boiling in water, though it is scarcely, if at all, acted upon by that fluid when cold. Its habitudes and products with the fire, or with nitric acid, are nearly the same as those of gum and of sugar. It appears to be as much more remote from the saline state than gum, as gum is more remote from that state than sugar.

The vegetable gluten, though it existed before the washing, in the pulverulent form, and has acquired its tenacity and adhesive qualities from the water it has imbibed, is nevertheless totally insoluble in this fluid. It has scarcely any taste. When dry, it is semi-transparent, and resembles glue in its colour and appearance. If it be drawn out thin, when first obtained, it may be dried by exposure to the air; but if it be exposed to warmth and moisture while wet, it putrefies like an animal substance. The dried gluten applied to the flame of a candle, crackles, swells, and burns exactly like a feather, or piece of horn. It affords the same products by destructive distillation as animal matters do; is not soluble in alcohol, oils, or ether, and is acted upon by acids and alkalis, when heated. According to Rouelle, it is the same with the caseous substance of milk.

* *Gluten of Wheat.*—M. Taddey, an Italian chemist, has lately ascertained that the gluten of wheat may be decomposed into two principles, which he has distinguished by the names, *gliadin*e (from γλια gluten), and *zimome* (from ζυμη ferment). They are obtained in a separate state by kneading the fresh gluten in successive portions of alcohol, as long as that liquid continues to become milky, when diluted with water. The alcohol solutions being set aside, gradually deposite a whitish matter, consisting of small filaments of gluten, and become perfectly transparent. Being now left to slow evaporation, the gliadine remains behind, of the consistence of honey, and mixed with a little yellow resinous matter, from which it may be freed, by digestion in sulphuric ether, in which gliadine is not sensibly soluble. The portion of the gluten not dissolved by the alcohol is the *zimome.*

Properties of Gliadine.—When dry, it has a straw-yellow colour, slightly transparent, and in thin plates, brittle, having a slight smell, similar to that of honeycomb, and, when slightly heated, giving out an odour similar to that of boiled apples. In the mouth, it becomes adhesive, and has a sweetish and balsamic taste. It is pretty soluble in boiling alcohol, which loses its transparency in proportion as it cools, and then retains only a small quantity in solution. It forms a kind of varnish in those bodies to which it is applied. It softens, but does not dissolve in cold distilled water. At a boiling heat it is converted into froth, and the liquid remains slightly milky. It is specifically heavier than water.

The alcoholic solution of gliadine becomes milky, when mixed with water, and is precipitated in white flocks by the alkaline carbonates. It is scarcely affected by the mineral and vegetable acids. Dry gliadine dissolves in caustic alkalis and in acids. It swells upon red-hot coals, and then contracts in the manner of animal substances. It burns with a pretty lively flame, and leaves behind it a light spongy charcoal, difficult to incinerate. Gliadine, in some respects, approaches the properties of resins; but differs from them in being insoluble in sulphuric ether. It is very sensibly affected by the infusion of nut-galls. It is capable of itself of undergoing a slow fermentation, and produces fermentation in saccharine substances.

From the flour of barley, rye, or oats, no gluten can be extracted, as from that of wheat, probably because they contain too small a quantity.* See Zimome.

* Gneiss. A compound rock, consisting of feldspar, quartz, and mica, disposed in slates, from the predominance of the mica scales. Its structure is called by Werner, granular-slaty. This geognostic formation is always stratified; contains sometimes crystals of schorl, tourmaline, and garnet, and is peculiarly rich in metallic ores.*

Gold is a yellow metal, of specific gravity 19.3. It is soft, very tough, ductile, and malleable; unalterable and fixed, whether exposed to the atmosphere, or to the strongest heat of furnaces. Powerful burning mirrors have volatilized it; and it has been driven up in fumes, in the metallic state, by flame urged upon it by a stream of oxygen gas. The electric shock converts it into a purple oxide, as may be seen by transmitting that commotion through gold leaf, between two plates of glass; or by causing the explosive spark of three or more square feet of coated glass, to fall upon a gilded surface. A heat of 32° W. or perhaps 1300° F. is required to melt it, which does not happen till after ignition. Its colour when melted, is of a bluish-green; and the same colour is exhibited, by light transmitted through gold leaf.

The limits of the ductility and malleability of gold are not known.

The method of extending gold used by the gold-beaters, consists in hammering a number of thin rolled plates between skins or animal membranes. By the weight and measure of the best wrought gold leaf, it is found, that one grain is made to cover 56¾ square inches; and from the specific gravity of the metal, together with this admeasurement, it follows that the leaf itself is $\frac{1}{282000}$ part of an inch thick. This, however, is not the limit of the malleability of gold; for the gold-beaters find it necessary to add three grains of copper in the ounce to harden the gold, which otherwise would pass round the regularities of the newest skins, and not over them; and in using the old skins, which are not so perfect and smooth, they proceed so far as to add twelve grains. The wire which is used by the lacemakers, is drawn from an ingot of silver, previously gilded. In this way, from the known diameter of the wire, or breadth when flattened, and its length, together with the quantity of gold used, it is found, by computation, that the covering of gold is only one 12th part of the thickness of gold-leaf, though it is still so perfect as to exhibit no cracks when viewed by a microscope.

No acid acts readily upon gold but aqua regia, and aqueous chlorine. Chromic acid added to the muriatic, enables it to dissolve gold.

The small degree of concentration, of which aqueous chlorine is susceptible, and the imperfect action of the latter acids, render aqua regia the most convenient solvent for this metal.

When gold is immersed in aqua regia, an effervescence takes place; the solution tinges animal matters of a deep purple, and corrodes them. By careful evaporation, fine crystals of a topaz colour are obtained. The gold is precipitated from its solvent, by a great number of substances. Lime and magnesia precipitate it in the form of a yellowish powder. Alkalis exhibit the same appearance; but an excess of alkali redissolves the precipitate. The precipitate of gold obtained from aqua regia by the addition of a fixed alkali, appears to be a true oxide, and is soluble in the sulphuric, nitric, and muriatic acids; from which, however, it separates by standing, or by evaporation of the acids. Gallic acid precipitates gold of a reddish colour, very soluble in the nitric acid, to which it communicates a fine blue colour.

Ammonia precipitates the solution of gold much more readily than fixed alkalis. This precipitate, which is of a brown, yellow, or orange colour, possesses the property of detonating with a very considerable noise when gently heated. It is known by the name of fulminating gold. The presence of ammonia is necessary to give the fulminating property to the precipitate of gold; and it will be produced by precipitating it with fixed alkali, from an aqua regia previously made by adding sal ammoniac to nitric acid; or by precipitating the gold from pure aqua regia, by means of sal ammoniac, instead of the ammonia alone. The fulminating gold weighs one-fourth more than the gold made use of. A considerable degree of precaution is necessary in preparing this substance. It ought not to be dried but in the open air, at a distance from a fire, because a very gentle heat may cause it to explode. Several fatal accidents have arisen from its explosion, in consequence of the friction of ground stoppers in bottles containing this substance, of which a small portion remained in the neck.

Fulminating gold, when exposed by Berthollet to a very gentle heat in a copper tube, with the pneumatical apparatus of mercury, was deprived of its fulminating quality, and converted into an oxide, at the same time that ammoniacal gas was disengaged. From this dangerous experiment it is ascertained, that fulminating gold consists of oxide of gold combined with ammonia. The same eminent philosopher caused fulminating gold to explode in copper vessels. Nitrogen gas was disengaged, a few drops of water appeared, and the gold was reduced to the metallic form. In this experiment he infers, that the ammonia was decomposed; that the nitrogen, suddenly assuming the elastic state, caused the explosion, while the oxygen of the oxide united with the hydrogen of the alkali, and formed the water.

This satisfactory theory was still farther confirmed by the decomposition of fulminating gold, which takes place in consequence of the action of the concentrated sulphuric acid, of melted sulphur, fat oils, and ether; all which deprived it of its fulminating quality, by combining with its ammonia.

Sulphurets precipitate gold from its solvent, the alkali uniting with the acid, and the gold falling down combined with the sulphur; of which, however, it may be deprived by moderate heat.

Most metallic substances precipitate gold from aqua regia: lead, iron, and silver, precipitate it of a deep and dull purple colour; copper and iron throw it down in its metallic state; bismuth, zinc, and mercury, likewise precipitate it. A plate of tin, immersed in a solution of gold, affords a purple powder, called the purple powder of Cassius, which is used to paint in enamel.

Ether, naphtha, and essential oils, take gold from its solvent, and from liquors, which have been called potable gold. The gold which is precipitated by evaporation of these fluids, or by the addition of sulphate of iron to the solution of gold, is of the utmost purity.

Most metals unite with gold by fusion. With silver it forms a compound, which is paler in proportion to the quantity of silver added. It is remarkable, that a certain proportion, for example, a fifth part, renders it greenish. From this circumstance, as well as from that of a considerable proportion of these metals separating from each other by fusion, in consequence of their different specific gravities, when their proportions do not greatly differ, it should seem, that their union is little more than a mere mixture without combination; for, as gold leaf transmits the green rays of light, it will easily follow, that particles of silver, enveloped in particles of gold, will reflect a green instead of a white light.

A strong heat is necessary to combine platina with gold: it greatly alters the colour of the gold, if its weight exceed the forty-seventh part of the mass.

Mercury is strongly disposed to unite with gold, in all proportions with which it forms an amalgam: this, like other amalgams, is softer the larger the proportion of mercury. It softens and liquefies by heat, and crystallizes by cooling.

Lead unites with gold, and considerably impairs its ductility; one-fourth of a grain to an ounce rendering it completely brittle. Copper renders gold less ductile, harder, more fusible, and of a deeper colour. This is the usual addition in coin, and other articles used in society. Tin renders it brittle in proportion to its quantity; but it is a common error of chemical writers to say, that the slightest addition is sufficient for this purpose. When alloyed with tin, however, it will not bear a red heat. With iron it forms a gray mixture, which obeys the magnet. This metal is very hard, and is said to be much superior to steel for the fabrication of cutting instruments. Bismuth renders gold white and brittle; as do likewise nickel, manganese, arsenic, and antimony. Zinc produces the same effect; and, when equal in weight to the gold, a metal of a fine grain is produced, which is said to be well adapted to form the mirrors of reflecting telescopes, on account of the fine polish it is susceptible of, and its not being subject to tarnish. The alloys of gold with molybdena are not known. It could not be mixed with tungsten, on account of the infusibility of this last substance. Mr. Hatchett gives the following order of different metals, arranged as they diminish the ductility of gold: bismuth, lead, antimony, arsenic, zinc, cobalt, manganese, nickel, tin, iron, platina, copper, silver. The first three were nearly equal in effect; and the platina was not quite pure.

For the purposes of coin Mr. Hatchett considers an alloy of equal parts of silver and copper as to be preferred, and copper alone as preferable to silver alone.

* The peroxide of gold thrown down by potash, from a solution of the neutral muriate, consists, according to Berzelius, of 100 gold, and 12 oxygen. It is probably a tritoxide. The protoxide of a greenish co-

lour, is procured by treating with potash-water, muriate of gold, after heat has expelled the chlorine. It seems to consist of 100 metal + 4 oxygen. The prime equivalent of gold comes out apparently 25.*

The gold coins of Great Britain contain eleven parts of gold, and one of copper. See Assay, Gilding, and Ores of Gold.

* **Gorgonia Nobilis.** The red coral. It consists of an interior stem, composed of gelatinous matter and carbonate of lime, with a cortex, consisting of membrane with carbonate of lime, coloured by some unknown substance *

Goulard's Extract. A saturated solution of subacetate of lead. See Lead.

* **Gouty Concretions.** These have been called chalk-stones from their appearance; but Dr. Wollaston first demonstrated their true composition to be uric acid, combined with ammonia, and thus explained the mysterious pathological relation between gout and gravel. See Concretion (Urinary).

Gouty concretions are soft and friable. They are insoluble in cold, but slightly in boiling water. An acid being added to this solution, seizes the soda, and the uric acid is deposited in small crystals. These concretions dissolve readily in water of potash. An artificial compound may be made by triturating uric acid and soda with warm water, which exactly resembles gouty concretions, in its chemical constitution.*

* **Grainer.** The lixivium obtained by infusing pigeons' dung in water, is used for giving flexibility to skins in the process of tanning, and is called the grainer.*

* **Grammatite.** See Tremolite.*

* **Granatite.** See Grenatite.*.

* **Granite.** A compound rock, consisting of quartz, feldspar, and mica, each crystallized and cohering by mutual affinity, without any basis or cement. The feldspar commonly predominates, and the mica is in smallest quantity. The colours of the feldspar are white, red, gray, and green. The quartz is light gray, and the mica dark. The granular crystals vary exceedingly in size, in different granite rocks. Occasionally granite is stratified; but sometimes no stratification can be perceived. Large globular masses, called rolling stones, are frequently met with, composed each of concentric lamellar concretions. Schorl, garnet, and tinstone are frequently present in granite. Tin and iron are the only metals abundantly found in this rock. It contains molybdena, silver, copper, lead, bismuth, arsenic, titanium, tungsten, and cobalt. It is, however, poorer in ores than many other rock formations.*

Granulation; the method of dividing metallic substances into grains or small particles, in order to facilitate their combination with other substances, and sometimes for the purpose of readily subdividing them by weight.

This is done either by pouring the melted metal into water, or by agitating it in a box until the moment of congelation, at which instant it becomes converted into a powder.

Various contrivances are used to prevent danger, and insure success, in the several manufactories that require granulation. Copper is granulated for making brass, by pouring it through a perforated ladle into a covered vessel of water with a moveable false bottom. A compound metal, consisting chiefly of lead, is poured into water through a perforated vessel of another kind, for making small-shot, in which the height above the surface of the fluid requires particular adjustment. In a new manufactory of this kind, the height is upward of 100 feet.

* **Graphite.** Rhomboidal graphite of Jameson, or plumbago, of which he gives two sub-species, the scaly and compact.

1st, *Scaly Graphite.* Colour dark steel-gray, approaching to iron-black. It occurs massive, disseminated and crystallized. The primitive form is a rhomboid. The secondary form is the equiangular six-sided table. Lustre splendent, metallic. Cleavage single. Fracture scaly foliated. Streak shining and metallic. Hardness sometimes equal to that of gypsum.

Perfectly sectile. Rather difficultly frangible. It writes and soils. Streak on paper black. Feels very greasy. Sp. gr. from 1.9 to 2.4.

2d, *Compact Graphite.* Colour rather blacker than preceding. Massive, disseminated and in columnar concretions. Internal lustre glimmering and metallic. Fracture small grained uneven, passing into conchoidal. When heated in a furnace, it burns without flame or smoke, forming carbonic acid, and leaving a residuum of iron. Its constituents are, carbon 91, iron 9.—*Berthollet.* It sometimes contains nickel, chromium, manganese, and oxide of titanium. It usually occurs in beds, sometimes disseminated and in imbedded masses, in granite, gneiss, mica-slate, clay-slate, foliated granular limestone, coal and trap formations. It is found in gneiss in Glen Strath Farrar in Inverness-shire; in the coal formation near Cumnock in Ayrshire, where it is imbedded in greenstone, and in Columnar glance-coal. At Borrodale in Cumberland, it occurs in beds of very varying thickness, included in a bed of trap, which is subordinate to clay-slate; and in many places on the continent, and elsewhere. The finer kinds are first boiled in oil, and then cut into tables for pencils. Grates are blackened with it, and crucibles formed of a mixture of it and clay.—*Jameson.*

GRAVITY, a term used by physical writers to denote the cause, by which all bodies move toward each other, unless prevented by some other force or obstacle. See ATTRACTION.

GRAVITY (SPECIFIC). See SPECIFIC GRAVITY.

For the specific gravities of different kinds of elastic fluids, see the table at the article GAS.

* GRAYWACKE. A mountain formation, consisting of two similar rocks, which alternate with, and pass into each other, called graywacke, and graywacke-slate. The first possesses the characters of the formation. It is a rock composed of pieces of quartz, flinty-slate, feldspar, and clay-slate, cemented by a clay-slate basis. These pieces vary in size from a hen's egg to little grains. When the texture becomes exceedingly fine grained, the rock constitutes graywacke-slate. Its colour is usually ash or smoke-gray, without the yellowish-gray, or greenish tinge, frequent in primitive slate. It has not the continuous lustre of primitive slate, but glimmers from interspersed scales of mica. It contains quartz veins, but no beds of quartz. Petrifactions are found in it. These rocks are stratified, forming, when alone, round-backed hills, with deep valleys between them. Immense beds of trap, flinty-slate, and transition limestone, are contained in this formation; as well as numerous metallic ores in beds and large veins.*

* GREEK FIRE. Asphaltum is supposed to have been its chief constituent, along with nitre and sulphur.*

* GREEN-EARTH. Colour celandine-green, and green of darker shades. Massive, and in globular and amygdaloidal shaped pieces, sometimes hollow, or as encrusting agate balls. Dull. Fracture earthy. Opaque. Feebly glistening in the streak. Soft and sectile. Rather greasy. Adheres slightly to the tongue. Sp. gr. 2.6. Before the blow-pipe, it is converted into a black vesicular slag. Its constituents are silica, 53, oxide of iron 28, magnesia 2, potash 10, water 6. It is a frequent mineral in the amygdaloid of Scotland, England, Ireland, Iceland, and the Faroe Islands. It occurs in Saxony, near Verona, the Tyrol, and Hungary. It is the *mountain-green* of artists in water colours. Its colour is durable, but not so bright as that from copper. The *green-earth* of Verona, of which the analysis is given above, is most esteemed.—*Jameson.**

* GREENSTONE. A rock of the *trap* formation, consisting of hornblende and feldspar, both in the state of grains, or small crystals. The hornblende is commonly most abundant, and communicates a green tinge to the feldspar.*

* GRENATITE, or prismatic garnet. See STAUROTIDE.*

* GUAIACUM. A resinous-looking substance, extracted from the very dense wood of a tree growing in the West Indies, called *guaiacum officinale.*

It differs however from resins in its habitudes with nitric acid, as Mr. Hatchett first showed. Its sp. gr. is 1.229. Its colour is yellowish-brown, but it becomes green on exposure to light. It is transparent and breaks with a resinous fracture. Its odour is not disagreeable, but when a very little of its powder, mixed with water, is swallowed, it excites a very unpleasant burning sensation in the fauces and stomach. Heat fuses it, with the exhalation of a somewhat fragrant smell.

Water dissolves a certain portion of it, acquiring a brownish tinge, and sweetish taste. The soluble matter is left when the water is evaporated. It constitutes 9 per cent of the whole, and resembles what some chemists call extractive.

Guaiacum is very soluble in alcohol. This solution, which is brown coloured, is decomposed by water. Aqueous chlorine throws down a pale blue precipitate from it.

Guaiacum dissolves readily in alkaline leys, and in sulphuric acid; and in the nitric with effervescence. From the solution in the last liquid, oxalic acid may be procured by evaporation, but no artificial tannin can be obtained, as from the action of nitric acid on the other resins.

Guaiacum distilled in close vessels, leaves 30.5 per cent of charcoal, being nearly double the quantity from an equal weight of the common resins. From Dr. Wollaston's experiments, it would appear that both air and light are necessary to produce the change in guaiacum from yellow to green. And Mr. Brande found that this green colour was more rapidly brought on in oxygen, than in common air. With nitric acid, or chlorine, it becomes green, next blue, and lastly brown.*

Formerly guaiacum was much commended in syphilis and other complaints; at present it is used chiefly in rheumatism, dissolved in liquid ammonia.

GUANO. A substance found on many of the small islands in the South Sea, which are the resort of numerous flocks of birds, particularly of the ardea and phænicopteros genus. It is dug from beds 50 or 60 feet thick, and used as a valuble manure in Peru, chiefly for Indian corn. It is of a dirty yellow colour, nearly insipid to the taste, but has a powerful smell partaking of castor and valerian. According to the analyses of Fourcroy and Vauquelin, about one-fourth of it is uric acid partly saturated with ammonia and lime. It contains

H.

* HÆMATITES. An ore of iron.*

HAIR. From numerous experiments M. Vauquelin infers, that black hair is formed of nine different substances, namely;

1. An animal matter, which constitutes the greater part. 2. A white concrete oil in small quantity. 3. Another oil of a grayish-green colour, more abundant than the former. 4. Iron, the state of which in the hair is uncertain. 5. A few particles of oxide of manganese. 6. Phosphate of lime. 7. Carbonate of lime, in very small quantity. 8. Silex, in a conspicuous quantity. 9. Lastly, a considerable quantity of sulphur.

The same experiments show, that red hair differs from black, only in containing a red oil instead of a blackish-green oil, and that white hair differs from both these, only in the oil being nearly colourless, and in containing phosphate of magnesia, which is not found in them.

* HARMOTOME. CROSS-STONE.*

* HARTSHORN, (SPIRIT OF). See AMMONIA.*

* HAUYNE. Colour blue of various shades. It occurs imbedded in grains, and rarely crystallized; in acute oblique double four-sided pyramids, variously truncated. Externally it is generally smooth, and edges rounded. Lustre splendent, to glistening, and vitreous. Cleavage quintuple. Fracture imperfect conchoidal. Transparent and translucent. Harder than apatite, but softer than feldspar. Brittle. Easily frangible. Sp. gr. 2.7. It melts with difficulty before the blow-pipe, into a white nearly opaque vesicular bead. With borax it melts into a transparent wine-yellow glass. With acids, it forms a transparent jelly. Its constituents are, silica 30, alumina 15, lime 13.5, sulphuric acid 12, potash 11, iron 1, loss 17.5.—*Vauquelin;* but by Gmelin, we have silica 35.48, alumina 18.87, lime 11.79, sulphuric acid 12.6, potash 15.45, iron 1.16, loss 3.45. It occurs imbedded in the basalt rocks of Albano and Frescati. Professor Jameson thinks it nearly allied to azure-stone.*

* HEAVY SPAR. Baryte. This genus is divided by Professor Jameson into 4 species; rhomboidal, prismatic, di-prismatic, and axifrangible.

1. *Rhomboidal baryte*, or *Witherite.* Colours, white, gray, and yellow. Massive. Disseminated, in various imitative shapes, and crystallized. The primitive form is a rhomboid of 88° 6′ and 91° 54′. The secondary forms are, the equiangular six-sided prism, truncated, or acutely acuminated, and the acute double six-sided pyramid. Prisms scopiformly grouped, or in druses. Lustre glistening, and resinous. Cleavage three-fold. Principal fracture uneven. Translucent. Harder than calcareous spar. Easily frangible. Sp. gr. 4.3. Before the blow-pipe it decrepitates slightly, and melts readily into a white enamel; soluble with effervescence in dilute nitric acid. It is carbonate of barytes, with occasionally 1 per cent of carbonate of strontites and sulphate of barytes. It occurs in Cumberland and Durham, in lead veins that traverse a secondary limestone, which rests on red sandstone. It is an active poison, and is employed for killing rats.

2. *Prismatic baryte*, or *Heavy spar.* Of this there are 9 sub-species; earthy, compact, granular, curved lamellar, straight lamellar, fibrous, radiated, columnar, and prismatic. They are all sulphates of barytes in composition. On account of its forms of crystallization, we shall describe the *fresh straight lamellar* heavy spar.

Its colours are white, gray, blue, green, yellow, red, and brown. Massive, in distinct concretions, and crystallized. The primitive form is an oblique, four-sided prism of 101° 53′. The following are the secondary forms: the rectangular four-sided table; the oblique four-sided table, perfect or variously truncated or bevelled; the longish six-sided table, perfect or bevelled; the eight-sided table, perfect or bevelled. Lustre splendent, between resinous and pearly. Cleavage, parallel with the planes of the primitive prism. Fragments rhomboidal and tabular. Translucent or transparent, and refracts double. Scratches calcareous spar, but is scratched by fluor spar. Brittle. Sp. gr. 4.1 to 4.6. It decrepitates briskly before the blow-pipe, and then melts into a white enamel. It phosphoresces on glowing coals with a yellow light. It is sulphate of barytes, with 0.85 sulphate of strontites, and 80 oxide of iron. It is found almost always in veins, which occur in granite, gneiss, mica-slate, and other rocks. The flesh-red variety is often accompanied with valuable ores. In Great Britain, it occurs in veins of different primitive and transition rocks, and in secondary limestone, &c. in the lead mines of Cumberland, Durham, and Westmoreland.

3. *Di-prismatic baryte*, or *Strontianite.*—Colour, pale asparagus-green, yellowish-white, and greenish-gray. Massive, in distinct concretions, and crystallized. The primitive form is an oblique four-sided prism, bevelled on the extremities. Secondary figures are, the acicular six-sided prism, and the acicular acute double six-sided pyramid. Lustre glistening or pearly.

Cleavage, in the direction of the lateral planes of the primitive form. Fracture fine grained uneven. Translucent. Harder than calcareous spar, but softer than fluor. Brittle. Sp. gr. 3.7. Infusible before the blow-pipe, but becomes white and opaque, tinging the flame of a dark purple colour. It is soluble with effervescence in dilute nitric or muriatic acid; and paper dipped in the solutions thus produced, burns with a purple flame. Its constituents are,

Strontian,	61.21	69.5	62.0	74.0
Carbonic acid,	30.20	30.0	30.0	25.0
Water,	8.50	0.5	8.0	0.5
	100.0	100.0	100.0	100.0
	Hope.	*Klapr.*	*Pelle.*	*Bucholz.*

It occurs at Strontian in Argillshire, in veins that traverse gneiss, along with galena, heavy spar, and calcareous spar. "The peculiar earth which characterizes this mineral, was discovered by Dr. Hope, and its various properties were made known to the public in his excellent Memoir on Strontites, inserted in the Transactions of the Royal Society of Edinburgh, for the year 1790."—*Jameson*, vol. ii. whose account of the preceding species is a model of mineralogical description.

4. *Axifrangible baryte*, or *Celestine*.—Of this there are five sub-species; foliated, prismatic, fibrous, radiated, and fine granular. We shall describe the foliated, and refer to Professor Jameson's work for the rest.

Colours white, gray, blue, and flesh-red. Massive, in lamellar concretions, and crystallized; in the rectangular four-sided table, in which the terminal planes are bevelled, and in the rectangular four-sided table, bevelled on the terminal edges. Lustre splendent, pearly. Cleavage threefold. Fracture uneven; fragments rhomboidal. Translucent. Scratches calcareous spar, but is scratched by fluor spar. Sectile, and easily frangible. Sp. gr. 3.9. It melts before the blow-pipe into a white friable enamel, without very sensibly tinging the flame. It is sulphate of strontites, with about 2 per cent of sulphate of barytes. It occurs in traptuff, in the Calton-hill at Edinburgh, and in red sandstone at Inverness. It is abundant in the neighbourhood of Bristol.—*Jameson.**

Heat. See Caloric.

* **Heliotrope.** A sub-species of rhomboidal quartz. Colour, green of various shades. The blood and scarlet-red, and the ochre-yellow dots and spots, are owing to disseminated jasper. Massive, and in angular and rolled pieces. Lustre glistening, resinous. Fracture conchoidal.* Translucent on the edges. Easily frangible. Hard, but softer than calcedony. Rather heavy. Sp. gr. 2.63. It is infusible before the blow-pipe. Its constituents are, silica 84, alumina 7.5, and iron 5. It is found in rocks belonging to the secondary trap formation. The finest heliotrope comes from Bucharia and Siberia. A variety is found in the island of Rume in Scotland. It is cut into seals and snuff-boxes. The Siberian wants the red spots.—*Jameson.**

Heliotropium. Turnsole. See Archil.

* **Hellebore.** The root of a plant formerly used in medicine, but now nearly discarded from practice, in consequence of the violence of its operation. Vauquelin ascribes its acrimony to a peculiar oil, which he separated from the infusion in alcohol, by distilling off the latter. It is very poisonous. Orfila says, on the contrary, that the poisonous quality of hellebore root resides in a principle soluble in water; and the powdered root is more certainly fatal, when applied to a wound, than when swallowed; that the white hellebore is more active than the black; and that the alkaline extract, which forms a part of the tonic pills of Bacher, is also very powerful. Vomiting is the only antidote.*

* **Helvine.** A sub-species of dodecahedral garnet. Colour wax-yellow. Disseminated, in small granular concretions, and crystallized in small tetrahedrons. Glimmering, or shining. Fracture, small grained, uneven. Crystals, strongly translucent. Softer than quartz, but harder than feldspar. Brittle. Sp. gr. 3 2 to 3.3. It melts easily into a blackish-brown glass. It occurs along with slate-spar, brown blende, and fluor spar, in beds subordinate to gneiss, near Schwartzenberg in Saxony.*

* **Hematin.** The colouring principle of logwood, the *hematoxylon campechianum* of botanists.

On the watery extract of logwood, digest alcohol for a day, filter the solution, evaporate, add a little water, evaporate gently again, and then leave the liquid at rest. Hematin is deposited in small crystals, which after washing with alcohol, are brilliant, and of a reddish-white colour. Their taste is bitter, acrid, and slightly astringent.

Hematin forms an orange-red solution with boiling water, becoming yellow as it cools, but recovering with increase of heat, its former hue. Excess of alkali converts it first to purple, then to violet, and lastly, to brown: in which state the hematin seems to be decomposed. Metallic oxides unite with hematin, forming a blue-coloured compound. Gelatin throws down reddish flocculi. Peroxide of tin, and acid, merely redden it.*

* **Hepar Sulphuris.** A name anciently given to alkaline and earthy sulphurets, from their liver-brown colour.*

* **Hepatic Air.** Sulphuretted hydrogen gas.*

* HEPATITE. Fetid, straight, lamellar, heavy spar. A variety of lamellar barytes, containing a minute portion of sulphur; in consequence of which, when it is heated or rubbed, it emits a fetid sulphurous odour.*

* HIGHGATE RESIN. See FOSSIL COPAL.*

* HOLLOW SPAR. *Chiastolite.**

* HOLMITE. A new mineral, which occurs crystallized in the form of an oblique four-sided prism, and having a sp. gravity of 3.597. Its constituents are 27 lime, 21 carbonic acid, 6½ alumina, 6½ silica, 29 oxide of iron, and 10 water.*

* HONE. The whet-slate of mineralogists.*

* HONEY. It is supposed to consist of sugar, mucilage, and an acid.*

* HONEY-STONE. MELLITE. Crystallized Harz of Mohs; the pyramidal honey-stone of Jameson. Colour honey-yellow. Rarely massive, but very distinctly crystallized. The primitive form is a pyramid of 118° 4′ and 93° 22′. The following are some of the secondary figures: 1*st*, The primitive pyramid, truncated on the apices, or on the apices and angles; 2*d*, These truncations giving rise to a low rectangular four-sided prism, or to an irregular rhomboidal dodecahedron; 3*d*, The angles in the common base flatly bevelled. Lustre splendent. Cleavage pyramidal. Fracture conchoidal. Semi-transparent. Refracts double. Harder than gypsum, but not so hard as calcareous spar. Brittle. Sp. gr. 1.56. Before the blow-pipe it becomes white and opaque, with black spots, and is at length reduced to ashes. Heated in a glass tube, it becomes black. Friction makes it slightly resino-electric. Its constituents are, 16 alumina, 46 mellitic acid, and 38 water.

It occurs superimposed on bituminous wood and earth-coal, and is usually accompanied with sulphur, at Artern in Thuringia. See the sequel of amber, for the criteria between it and mellite.*

* HOMBERG'S PYROPHORUS. Ignited muriate of lime.*

* HOOFS OF ANIMALS. Coagulated albumen, like horn.*

* HORN. An animal substance, chiefly membranous, composed of coagulated albumen, with a little gelatin, and about half a per cent of phosphate of lime. But the horns of the buck and hart are of a different nature, being intermediate between bone and horn.*

* HORN SILVER. Chloride of Silver.*

* HORNBLENDE. A sub-species of straight-edged augite. There are three varieties of hornblende; the common, hornblende-slate, and basaltic hornblende.

1. *Common hornblende.* Colour, greenish-black, and black of other shades. Massive, disseminated and crystallized, in a broad, thin, very oblique, four-sided prism, and in a six-sided prism. The lateral planes of the prism are deeply longitudinally streaked. Lustre shining, pearly. Cleavage two-fold and oblique angular. Fracture uneven. The black hornblende is opaque, the green translucent on the edges. Harder than apatite, but not so hard as feldspar. Mountain-green streak. When breathed on, it yields a peculiar smell. Difficultly frangible. Sp. gr. 3.25. It melts before the blow-pipe, with violent ebullition into a grayish-black coloured glass. Its constituents are, 42 silica, 12 alumina, 11 lime, 2.25 magnesia, 30 oxide of iron, 0.25 ferruginous manganese, and 0.75 water, with a trace of potash. It is an essential ingredient of the mountain rocks, syenite and greenstone, and it occurs frequently in granite, gneiss, &c. It is found abundantly in the British Islands, and on the Continent.

2. *Hornblende-slate.* Colour intermediate between greenish-black and blackish-green. Massive. Lustre glistening or pearly. Fracture straight slaty. Fragments tabular. Opaque. Streak greenish. Semi-hard. Difficultly frangible. It occurs in beds in gneiss, in Aberdeenshire, Banffshire, and Argyllshire, in many parts of England and Ireland, and abundantly on the Continent.

3. *Basaltic Hornblende.* Colour, velvet-black, or brownish-black. It occurs crystallized, in the following figures:—an unequiangular six-sided prism, and the six-sided prism, both variously acuminated. Lustre of the cleavage, which is double, is splendent, approaching to pearly. Fracture small grained uneven. Opaque. Rather harder than common hornblende, and more easily frangible. Streak dark grayish-white. Sp. gr. 3.16. It fuses into a black glass. Its constituents are, 47 silica, 26 alumina, 8 lime, 2 magnesia, 15 oxide of iron, and 0.5 water. It occurs imbedded in basalt, along with olivine and augite, at Arthur's Seat, near Edinburgh, in Fifeshire, and the Islands of Mull, Canna, Eigg, and Skye. In the basaltic rocks of England, Ireland, and the Continent.—*Jameson.**

* HORNSTONE. Professor Jameson's ninth sub-species of rhomboidal quartz. He divides it into splintery hornstone, conchoidal hornstone, and woodstone.

1. *Splintery hornstone.* Colours gray, red, and green. Massive, in balls, lenticular, and in six-sided prismatic supposititious crystals. Dull. Fracture splintery, and somewhat like horn in appearance, whence the name. Translucent on the edges. Less hard than quartz or flint. Difficultly frangible. Sp. gr. 2.6. Infusible before the blow-pipe. Its constituents are, 98.25 silica, 0.75 alumina, 0.50 oxide of iron, 0.50 water. It occurs in veins in primi-

tive countries, along with ores of silver, lead, zinc, copper, and iron, and forming the basis of hornstone porphyry. It is found in Arran, Perthshire, Argyllshire, and many other counties of Scotland, and abundantly on the Continent. Hornstone porphyry at Efsdale in Sweden, is cut into vases, candlesticks, &c. and the pedestal of the statue of Gustavus III. at Stockholm, is formed of it.

2. *Conchoidal hornstone.* Colours gray, white, and red. Massive, stalactitic, and rarely in supposititious crystals, whose figures originate from calcareous spar. Lustre glimmering. Fracture conchoidal. Less translucent than the preceding kind, but somewhat harder. Rather difficultly frangible. Sp. gr. 2.58. It occurs in metalliferous veins and agate veins, and along with clay-stone in the Pentland-hills.

3. *Woodstone.* Colours ash-gray and grayish-black. The various shades of colour, are in clouded and striped delineations. It occurs in rolled pieces, and in the shape of trunks, branches and roots. Surface uneven. Dull or glistening. Cross fracture, imperfect conchoidal; longitudinal, fibrous. Translucent on the edges. Hard in a low degree. Rather difficultly frangible. Sp. gr. 2.63. It is found imbedded in sandy loam in alluvial soil. It occurs near Lough Neagh, in Ireland; at Chemnitz and Hilbersdorf, in Upper Saxony. It receives a good polish.*—*Jameson.*

* **Horseradish Root**, yields by distillation, an acrid oil, denser than water.*

* **Hospital Ulcer**, the matter of, consists of a peculiar morbid secretion. It has been successfully treated by washing with dilute nitrate of mercury, nitric acid, and aqueous chlorine.*

* **Humite.** A mineral of a reddish-brown colour, which occurs crystallized in octohedrons, more or less truncated or bevelled. Planes transversely streaked. Lustre shining. Transparent. Scratches quartz with difficulty. It occurs at Somma, near Naples, in a rock composed of gray-coloured granular topaz. It was named by Count Bournon, in honour of Sir Abr. Hume, Bart. a distinguished cultivator of mineralogy.*

* **Hyacinth.** A sub-species of pyramidal zircon. Colours, red, brown, more rarely yellow, green, and gray. It occurs in angular grains, and crystallized in a rectangular four-sided prism, variously acuminated or truncated. Crystals are small. Lustre specular-splendent. Cleavage fourfold. Fracture small conchoidal. Semitransparent or transparent, and refracts double. Harder than quartz, but softer than topaz. Rather easily frangible. Sp. gr. 4.6 to 4.78. Before the blow-pipe it loses its colour, but not its transparency, and is infusible. Its constituents are,

	from Ceylon,	*from Expailly.*
Zircon,	70.00	66.00
Silica,	25.00	31.00
Oxide of iron,	0.50	2.00
Loss,	4.50	1.00
	100.00	100.00
	Klaproth.	*Vauquelin.*

It occurs imbedded in gneiss and syenite, in basalt and lava, and dispersed through alluvial soil; in Auvergne; near Pisa; in the trap rocks round Lisbon; by Professor Jameson in a rolled mass of syenite in the shire of Galloway; and abundantly in Ceylon.

The darker varieties are deprived of their colour by heat, a fact of which artists avail themselves to make zircon resemble diamond. It is esteemed as one of the gems by lapidaries.—*Jameson.**

* **Hyalite.** Colours yellowish and grayish-white. Generally small reniform, botrioidal, or stalactitic. Lustre splendent. Fracture small conchoidal. Translucent. Moderately hard. Sp. gr. 2.2. Infusible before the blow-pipe. Its constituents are, 92 silica, 6.33 water. It has been hitherto found principally near Frankfort on the Maine, where it occurs in fissures in vesicular basalt and basaltic greenstone. It is cut into ringstones.*

* **Hydrargyllite.** *Wavellite.**

* **Hydrates.** Compounds, in definite proportions, of metallic oxides with water.*

* **Hydriodates.** Salts consisting of hydriodic acid, combined in definite proportions with oxides.*

* **Hydriodic Acid.** See **Acid** (**Hydriodic**) and **Iodine.***

* **Hydrochloric Acid.** Muriatic acid gas; a compound of chlorine and hydrogen.*

* **Hydrocyanic Acid.** See **Acid** (**Prussic**).*

* **Hydrogen Gas.** The lightest species of ponderable matter hitherto known. It was discovered by Mr. Cavendish in 1766. It can be procured only from water, of which it forms an essential constituent.

Into a phial furnished with a bent tube fitted to its cork, or into a retort, put some pieces of pure redistilled zinc, or harpsichord iron wire, and pour on them sulphuric acid diluted with 5 times its bulk of water. An effervescence will ensue, occasioned by the decomposition of the water, and disengagement of hydrogen, which may be collected in the pneumatic apparatus. For very accurate researches, it must be received in jars over mercury, and exposed to the joint action of dry muriate of lime, and a low temperature. It is thus freed from hygrometric water. In this state its specific gravity is 0.0694 at

60° F. and 30 inches of barom. pressure. 100 cubic inches weigh 2.118 grains. It is therefore about 14.4 times less dense than common air; 16 times less dense than oxygen, and 14 times less dense than azote. In the article *Gas*, I have shown, that when it stands over water at 60°, its sp. gr. acquires an increase of nearly one-seventh; and it becomes about 0.0790. From the great rarity of hydrogen, it is employed for the purpose of inflating varnished silk bags, which are raised in the air, under the name of balloons. See AEROSTATION.*

This gas is colourless, and possessed of all the physical properties of air. It has usually a slight garlic odour, arising probably from arsenical particles derived from the zinc. When water is transmitted over pure iron in a state of ignition, it yields hydrogen free from smell. It is eminently combustible, and, if pure, burns with a yellowish-white flame; but from accidental contamination, its flame has frequently a reddish tinge. If a narrow jar filled with hydrogen, be lifted perpendicularly, with the bottom upwards, and a lighted taper be suddenly introduced, the taper will be extinguished, but the gas will burn at the surface, in contact with the air. Animal life is likewise speedily extinguished by the respiration of this gas, though Sir H. Davy has shown, that if the lungs be not previously exhausted by a forced expiration, it may be breathed for a few seconds without much seeming inconvenience. For its point of accension, see COMBUSTION; and for its habitudes with liquids and solids, see GAS.

When five measures of atmospheric air are mixed with two of hydrogen, and a lighted taper, or an electric spark, applied to the mixture, explosion takes place, three measures of gas disappear, and moisture is deposited on the inside of the glass. When two measures of hydrogen, mixed with one of oxygen, are detonated, the whole is condensed into water. Thus, therefore, we see the origin of the name *hydrogen*, a term derived from the Greek to denote the *water-former*. See WATER. If a bottle containing the effervescing mixture of iron and dilute sulphuric acid, be shut with a cork, having a straight tube of narrow bore fixed upright in it, then the hydrogen will issue in a jet, which being kindled, forms the philosophical candle of Dr. Priestley. If a long glass tube be held over the flame, moisture will speedily bedew its sides, and harmonic tones will soon begin to sound. Mr. Faraday, in an ingenious paper inserted in the 10th number of the Journal of Science, states, that carbonic oxide produces, by the action of its flame, similar sounds, and that therefore the effect is not due to the affections of aqueous vapour, as had formerly been supposed. He shows, that the sound is nothing more than the report of a continued explosion, agreeably to Sir H. Davy's just theory of the constitution of flame. Vapour of ether, made to burn from a small aperture, produces the same sonorous effect as the jet of hydrogen, of coal gas, or olefiant gas, on glass and other tubes. Globes from seven to two inches in diameter, with short necks, give very low tones; bottles, Florence flasks and phials, always succeeded; air jars from four inches diameter to a very small size, may be used. Some angular tubes were constructed of long narrow slips of glass and wood, placing three or four together, so as to form a triangular or square tube, tying them round with pack-thread. These held over the hydrogen jet, gave distinct tones.

Hydrogen, combined with oxygen,

With	forms water.
Chlorine,	muriatic acid.
Iodine,	hydriodic acid.
Prussine,	prussic acid.
Carbon,	subcarb. and carb. hydr.
Azote,	ammonia.
Phosphorus,	subphos. and phos. hydr.
Sulphur,	Sulph. and subsul. hydr.
Arsenic,	arsenuretted hydrogen.
Tellurium,	telluretted hydrogen.
Potassium,	potassuretted hydrogen.

For an account of these several compounds, see the respective bases. From the proportion in which it combines with these bodies, its prime equivalent on the oxygen radix, is fixed at 0.125. It is the body which gives the power of burning with flame to all the substances used for the economical production of heat and light.

In that invaluable repository of philosophical facts, Tilloch's Magazine, we have the following notice of the effect of hydrogen gas on the voice: "The *Journal Britannique*, published at Geneva by Prevost, contains the following article: 'Maunoir was one day amusing himself with Paul at Geneva, in breathing pure hydrogen air. He inspired it with ease, and did not perceive that it had any sensible effect on him, either in entering his lungs, or passing out. But after he had taken in a very large dose, he was desirous of speaking, and was astonishingly surprised at the sound of his voice, which was become soft, shrill, and even squeaking, so as to alarm him. Paul made the same experiment on himself, and the same effect was produced: I do not know whether any thing similar has occurred in breathing any of the other gases.'" *Vol.* iv. *page* 214.

In the article *arsenuretted hydrogen*, under ARSENIC, in this work, a sentence at the middle of the column should read thus, "By subtracting from the specific gravity of the arsenuretted gas, that of hydrogen gas × $\frac{140}{100}$, we have the proportion of arsenic present; 0.55520 — 0.09716 = 0.45804 = the arsenic in 100 measures of arsenuretted hydrogen; which gives the proportion by weight of about five arsenic to one hydrogen," &c.*

* **Hydroguret** of sulphur. See **Sulphur**.*

Hydrometer. The best method of weighing equal quantities of corrosive volatile fluids, to determine their specific gravities, appears to consist in enclosing them in a bottle with a conical stopper, in the side of which stopper a fine mark is cut with a file. The fluid being poured into the bottle, it is easy to put in the stopper, because the redundant fluid escapes through the notch, or mark, and may be carefully wiped off. Equal bulks of water, and other fluids, are by this means weighed to a great degree of accuracy, care being taken to keep the temperature as equal as possible, by avoiding any contact of the bottle with the hand, or otherwise. The bottle itself shows with much precision, by a rise or fall of the liquid in the notch of the stopper, whether any such change have taken place. See Specific Gravity and Alcohol.

The hydrometer of Fahrenheit consists of a hollow ball, with a counterpoise below, and a very slender stem above, terminating in a small dish. The middle, or half length of the stem, is distinguished by a fine line across. In this instrument every division of the stem is rejected, and it is immersed in all experiments to the middle of the stem, by placing proper weights in the little dish above. Then, as the part immersed is constantly of the same magnitude, and the whole weight of the hydrometer is known, this last weight added to the weights in the dish, will be equal to the weight of fluid displaced by the instrument, as all writers on hydrostatics prove. And accordingly, the sp. gravities for the common form of the tables will be had by the proportion:

As the whole weight of the hydrometer and its load, when adjusted in distilled water,
Is to the number 1000, &c.
So is the whole weight when adjusted in any other fluid,
To the number expressing its specific gravity.

The hydrometers, or *pese-liqueurs*, of Baumé, though in reality comparable with each other, are subject in part to the defect, that their results, having no independent numerical measure, require explanation to those who do not know the instruments.

Baumé's Hydrometer for Spirits.

Temperature 55° Fahrenheit, or 10° Reaumur.

Deg.	Sp. Grav.	Deg.	Sp. Grav.	Deg	Sp. Grav.	Deg.	Sp. Grav.	Deg.	Sp. Grav.
10	= 1.000	17	= .949	23	= .909	29	= .874	35	= .842
11	.990	18	.942	24	.903	30	.868	36	.837
12	.985	19	.935	25	.897	31	.862	37	.832
13	.977	20	.928	26	.892	32	.857	38	.827
14	.970	21	.922	27	.886	33	.852	39	.822
15	.963	22	.915	28	.880	34	.847	40	.817
16	.955								

With regard to the hydrometer for salts, the learned author of the first part of the Encyclopædia, Guyton de Morveau, who by no means considers this an accurate instrument, affirms, that the sixty-sixth degree corresponds nearly with a specific gravity of 1.848; and as this number lies near the extreme of the scale, I shall use it to deduce the rest.

Baumé's Hydrometer for Salts.

Temperature 55° Fahrenheit, or 10° Reaumur.

Deg.	Sp. Grav.	Deg.	Sp. Grav.	Deg.	Sp. Grav.	Deg.	Sp. Grav.	Deg.	Sp. Grav.
0	= 1.000	15	= 1.114	30	= 1.261	45	= 1.455	60	= 1.717
3	1.020	18	1.140	33	1.295	48	1.500	63	1.779
6	1.040	21	1.170	36	1.333	51	1.547	66	1.848
9	1.064	24	1.200	39	1.373	54	1.594	69	1.920
12	1.089	27	1.230	42	1.414	57	1.659	72	2.000

It may not be amiss to add, however that in the Philosophical Magazine, Mr. Bingley, the assay-master of the mint, has given the following numbers as the specific gravity of nitric acid, found to answer to the degrees of an areometer of Baumé by actual trial; temperature about 60° Fahr. But his appears to have been a different instrument, as it was graduated only from 0 to 50°.

Deg.	Sp. Grav.	Deg.	Sp. Grav.	Deg.	Sp. Grav.	Deg.	Sp. Grav.	Deg.	Sp. Grav.
18 =	1.150	29 =	1.250	34 =	1.300	38 =	1.350	42 =	1.400
20	1.167	30	1.267	35	1.312	39	1.358	43	1.416
26	1.216	31	1.275	36	1.333	40	1.367	45	1.435
28	1.233	32	1.283	37	1.342	41	1.383		

There are a variety of hydrometers used for determining the strength of ardent spirit. See Alcohol and Distillation.

* **Hydrophane.** A variety of opal, which has the property of becoming transparent on immersion in water. It is also called *oculus mundi*. We must be careful to immerse them only in pure water, and to withdraw them whenever they have acquired their full transparency. If we neglect these precautions, the pores will soon become filled with earthy particles deposited from the water, and the hydrophane will cease to exhibit this curious property, and will remain always more or less opaque.*

* **Hydrosulphurets.** Compounds of sulphuretted hydrogen with the salifiable bases.*

* **Hydrothionic Acid.** Sulphuretted hydrogen, the hydrosulphuric acid of M. Gay-Lussac.*

* **Hyosciama.** A new vegetable alkali, extracted by Dr. Brandes from the hyosciamus nigra, or henbane. It crystallizes in long prisms, and when neutralized by sulphuric acid, or nitric acid, forms characteristic salts.—The examination of the alkaline constituents of narcotic plants demands great circumspection, because in them the whole poisonous properties of the plant are concentrated. The vapour is particularly prejudicial to the eyes. The smallest morsel put upon the tongue, is very dangerous.*

* **Hypersthene.** Labradore schillerspar. Colour between grayish and greenish-black, but nearly copper-red on the cleavage. Massive, disseminated, and in thin curved lamellar concretions. Lustre shining, metallic, pearly. Cleavage double oblique angular. Opaque. Streak greenish-gray. Hard as feldspar. Brittle. Sp. gr. 3.4. Infusible before the blowpipe. Its constituents are, 54.25 silica, 14 magnesia, 2.25 alumina, 1.50 lime, 24.5 oxide of iron, 1 water, and a trace of manganese. It has been found in Labradore, Greenland, and by Dr. M'Culloch in the Isle of Skye. It has a beautiful copper-red colour when cut and polished into ringstones or broaches.*

* **Hypophosphorous Acid.** See Acid (Hypophosphorous.)*

* **Hyposulphurous Acid.** See Acid (Hyposulphurous.)*

* **Hyposulphuric Acid.** See Acid (Hyposulphuric,) which three acids are treated of under the phosphoric and sulphuric.

I & J.

* **Jade.** See Nephrite.*

Jalap. A root used in medicine as a purgative. By M. Henry's analysis, the constituents of three different varieties of this root are,

	Jal. leger.	Jal. sain.	Jal. pique.
Resin,	60	48	72
Extract,	75	140	125
Starch,	95	102	103
Woody fibre,	270	210	200
	500	500	500*

* **Jargon.** See Zircon.*

* **Jasper.** A sub-species of the rhomboidal quartz of Professor Jameson. He enumerates five kinds: Egyptian jasper, striped, porcelain, common, and agate jasper.

1. *Egyptian jasper*, of which there is red and brown. The first is flesh-red, blood-red, yellow, and brown, in ring-shaped delineations. In roundish pieces. Dull. Fracture conchoidal. Feebly translucent on the edges. Hard. Easily frangible. Sp. gr. 2.63. It is found imbedded in red clay-ironstone at Baden, and is cut into ornaments.

The *brown* has its various shades of colour disposed in concentric stripes, alternating with black stripes. In spheroidal masses. Lustre glimmering. Fracture conchoidal. Feebly translucent on the edges. As hard as hornstone. Sp. gr. 2.6. It is infusible. It occurs loose in the sands of Egypt. It is cut into ornaments.

2. *Striped jasper*. Colours, gray, green, yellow, red, arranged in stripes, in flamed or spotted delineations. Massive in whole beds. Dull. Fracture conchoidal. Opaque. Less hard than Egyptian jasper. Rather easily frangible. Sp. gr. 2.5. It occurs in secondary clay-porphyry in the Pentland-hills, and near Friburg in Saxony. It receives a fine polish.

3 *Porcelain jasper*. Colours gray, blue, yellow, generally of one colour, or with clouded delineations. Massive, and cracked in all directions. Lustre glistening. Fracture conchoidal. Opaque. Easily frangi-

ble, and not very hard. Sp. gr. 2.5. Fuses into a white or gray glass. Its constituents are 60.75 silica, 27.25 alumina, 3 magnesia, 2.5 oxide of iron, and 3.66 potash. It is always found along with burnt clay and earth slags. According to Werner, it is slate-clay converted into a kind of porcelain, by the heat of a pseudo-volcano, from beds of burning coal. It is found on the coast of Fifeshire, in Shropshire, and Warwickshire, and some parts of Germany, where immense beds of coal appear.

4. *Common jasper.* Colours red and brown. Massive. Lustre, from shining to dull. Fracture conchoidal. Opaque. Hard in a low degree. Rather easily frangible. Sp. gr. 2.6. Infusible before the blow-pipe, becoming at last white. It occurs principally in veins as a constituent of agate. It is found in the Pentland-hills, and in trap and transition rocks in Ayrshire and Dumfries-shire. It receives a good polish.

5. *Agate jasper.* Colours yellowish-white and reddish-white. Massive. Dull. Fracture flat conchoidal. Opaque. Hard in a low degree. It occurs in layers in agate balls, in many places.*

ICE. See CALORIC, THERMOMETER, WATER.

ICELAND SPAR. See CALCAREOUS SPAR.

ICE-SPAR. A sub-species of feldspar.

ICHTHYOPHTHALMITE. See APOPHYLLITE.

ICHTHYOCOLLA. Fish glue or *Isinglass.*

IDOCRASE. See VESUVIAN.

JELLY, of ripe currants and other berries; a compound of mucilage and acid, which loses its gelatinizing power by long boiling.

JENITE. See LIEVRITE.

JET. See PITCH COAL.

IGNIS FATUUS. A luminous appearance or flame, frequently seen in the night in different country places, and called in England *Jack with a lantern,* or *Will with the wisp.* It seems to be mostly occasioned by the extrication of phosphorus from rotting leaves and other vegetable matters. It is probable, that the motionless ignes fatui of Italy which are seen nightly on the same spot, are produced by the slow combustion of sulphur, emitted through clefts and apertures in the soil of that volcanic country.

INCINERATION. The combustion of vegetable or animal substances, for the purpose of obtainng their ashes or fixed residue.

INCOMBUSTIBLE CLOTH. See ASBESTUS.

INDIGO. A blue colouring matter extracted from a plant called Anil, or the Indigo Plant.

In the preparation of this drug, the herb is put into a vat or cistern, called the steeping trough, and there covered with water. The matter begins to ferment sooner or later, according to the warmth of the weather and the maturity of the plant; sometimes in six or eight hours, and sometimes in not less than twenty. The liquor grows hot, throws up a plentiful froth, thickens by degrees, and acquires a blue colour inclining to violet. At this time, without touching the herb, the liquor impregnated with its tincture, is let out by cocks in the bottom into another vat placed for that purpose, so as to be commanded by the first.

In the second vat, called the beating vat, the liquor is strongly and incessantly beaten with a kind of buckets fastened to poles, till the colouring matter is united into a body.

As soon as it is judged, from the blue colour of the liquid, that the beating is sufficient, it is left at rest for two hours; after which the clear liquor is drawn off by cocks in the side of the vat, and the blue part is discharged by another cock into a third vat, where it is suffered to settle for some time longer; then conveyed in a half fluid state into bags of cloth, to strain off more of its moisture; and lastly, exposed to the air in the shade in shallow wooden boxes, till it is thoroughly dry.

Bergmann examined this drug. He found, that one-ninth part of the indigo was taken up by boiling it in water. The parts dissolved were partly mucilaginous, partly astringent and partly saponaceous. The solution of alum, and of sulphate of iron as well as of copper, precipitate the astringent portion.

Bergmann mixed one part of well pulverized indigo with eight parts of colourless sulphuric acid, of the specific gravity of 1.900, in a glass vessel slightly closed. The acid very quickly acted upon the indigo, and excited much heat. After a digestion of twenty-four hours, the solution was effected; but the mixture was opaque and black.

If the sulphuric acid be first diluted in the water, it attacks only the earthy principle which is mixed with the indigo, and some of the mucilaginous parts.

The fixed alkalis saturated with carbonic acid, separate a very fine blue powder from the solution of indigo, which is deposited very slowly

The concentrated nitric acid attacks indigo with so much activity, as to set it on fire.

The muriatic acid by digestion, and even boiling upon indigo, takes up only the earthy matter, the iron, and a little of the extractive matter, which gives it a brown colour, but in no respect attacks the blue colour.

Pure or caustic fixed alkali dissolves some matters foreign to the colouring matter of the indigo, but acts very little on the colouring particles. Pure volatile alkali has nearly the same effect. Precipitated indigo is speedily dissolved in the cold, in the alkalis, whether fixed or volatile, if pure or caustic. The blue colour is gradually changed to a green, and at last destroyed.

Bergmann concludes, from his analysis, that 100 parts of good indigo contain of mucilaginous matter, separable by water 12, resinous matter soluble in alcohol 6, earthy matter taken up by the acetic acid, which does not attack the iron, here in the state of oxide, 22, oxide of iron taken up by the muriatic acid 13.

There remained 47 parts, which are the colouring matter, nearly in a state of purity, and afforded by distillation, carbonic acid 2, alkaline liquor 8, empyreumatic oil 9, coal 23.

The solubility of indigo in alkalis, appears to be produced by the abstraction of part of the oxygen it had absorbed. This appears to be well established from the experiment of Bergmann, wherein equal weights of sulphate of iron and indigo, and double the weight of lime, are mixed together in water, and produce a solution of the indigo in the lime-water. But if the iron of the sulphate, be previously oxidized to a higher degree, by boiling it in much water for several hours, and subsequent evaporation, the solution will not be effected, because the precipitated iron is no longer disposed to absorb oxygen. Or again, if indigo be added to a solution of caustic fixed alkali, and orpiment be added (which consists of arsenic and sulphur,) the indigo is soon dissolved, and takes a green colour. If the arsenic corresponding with the orpiment be only added, the bath will never be fit for the dyer; but if the quantity of sulphur it ought to contain be added, the appearances of solution will speedily be had.

It follows, therefore, that indigo contains oxygen in its natural state; that in this state it will not unite with lime or alkalis; but that substances capable of depriving it of part of its oxygen, render it soluble in lime or alkalis; and lastly, that the natural state of the indigo is restored by the contact of oxygen which it absorbs. In this last way it is that the blue dye is effected. The piece comes out of the vat of the same colour as the solution; viz. green; but becomes blue by exposure to the air. The alkali, or lime, is carried off by the washing, and the indigo remains combined with the stuff, by this means dyed.

* M. Chevreul has given the following results of a very elaborate analysis of Guatimala Indigo.

By water	Ammonia, Disoxygenized indigo, Green matter, Bitter matter,	12
By alcohol	Green matter, Red matter, Indigo,	30
By muriatic acid	Red matter,	6
	Carbonate of lime,	2
	Oxide of iron and alumina,	2
	Silica,	3
	Pure indigo,	45
		100

When commercial indigo is exposed to a heat of about 400° F. it evolves a beautiful crimson smoke, which may be condensed in crystalline needles, which are supposed to be pure indigo. The blue vat of the dyer contains indigo deoxidized by protoxide of iron, and rendered soluble in its yellow-green state by lime-water. If a portion of this solution be exposed in the air, in a shallow vessel, the indigo will speedily absorb oxygen, and precipitate in its usual state of an insoluble blue powder. This being dried, and digested in a mixture of alcohol and muriatic acid, becomes also pure indigo, by the abstraction of all the resin and lime. In this state, it is a soft powder, of an intensely deep blue, verging sometimes on purple. It is unchangeable by the air. Every substance which has a great affinity for oxygen, when digested with indigo, deprives it of the blue colour, and converts it, either permanently or for a time, to a yellow or greenish-yellow hue. Thus, if into the sulphate of indigo above described, are put a few pieces of iron or zinc, the nascent hydrogen seizes its oxygen, and discolours it. Sulphuric acid, rendered smoking by a little sulphurous acid, is a better solvent of indigo than pure oil of vitriol. By boiling a little sulphur in this, its solvent power is improved. Nitric acid, digested on indigo, converts it into Mr. Hatchett's artificial tannin, a bitter principle, with oxalic and benzoic acids.

When indigo is mixed with liquid fermentable materials, it is speedily deoxidized. Bergmann showed long ago, that no gas, except carbonic acid, was disengaged from the distillation of indigo in close vessels. This seems to coincide with Dr. Thomson's late analysis, in which he exposed pure indigo to the action of ignited peroxide of copper, and collected the gaseous products, which led him to assign the following as its composition:—

Oxygen,	46.154
Carbon,	40.384
Azote,	13.462
	100.000

The total want of hydrogen in this vegetable substance, is a very singular and interesting result. He says, that indigo, in the

state of a greenish-yellow soluble pigment, is composed of 5 atoms Oxygen, 5.00
7 Carbon, 5.25
1 Azote, 1.75
12.00

The addition of a single atom of oxygen, renders the pigment blue and insoluble. "Thus," adds he, "indigo exhibits a striking refutation of the old notion, that acidity is owing to the union of oxygen with an acidifiable basis. Blue indigo approaches much nearer to the nature of a salifiable base, than an acid; but deoxidized indigo, seems to possess acid powers, for it becomes capable of uniting with alkalis, and alkaline earths." *Annals of Philosophy for June* 1820.*

Ink. Every liquor or pigment used for writing or printing, is distinguished by the name of ink. Common practice knows only black and red.

Of black ink there are three principal kinds: 1. Indian ink; 2. Printer's ink; and, 3. Writing ink.

The Indian ink is used in China for writing with a brush, and for painting upon the soft flexible paper of Chinese manufacture. It is ascertained, as well from experiment as from information, that the cakes of this ink are made of lampblack and size, or animal glue, with the addition of perfumes or other substances not essential to its quality as an ink. The fine soot from the flame of a lamp or candle, received by holding a plate over it, mixed with clean size from shreds of parchment or glove-leather not dyed, will make an ink equal to that imported.

Good printer's ink is a black paint, smooth and uniform in its composition, of a firm black colour, and possesses a singular aptitude to adhere to paper thoroughly impregnated with moisture.

The consistence and tenacity of the oil in this composition are greatly increased, and its greasiness diminished, by means of fire, Linseed oil or nut oil is made choice of for this use. The nut oil is supposed to be the best, and is accordingly preferred for the black ink, though the darker colour it acquires from the fire renders it less fit for the red. It is said, that the other expressed oils cannot be sufficiently freed from their unctuous quality.

Ten or twelve gallons of the oil are set over the fire in an iron pot, capable of holding at least half as much more; for the oil swells up greatly, and its boiling over into the fire would be very dangerous. When it boils, it is kept stirring with an iron ladle; and if it do not itself take fire, it is kindled with a piece of flaming paper or wood; for simple boiling, without the actual accension of the oil, does not communicate a sufficient degree of the drying quality required. The oil is suffered to burn for half an hour or more, and the flame being then extinguished by covering the vessel close, the boiling is afterward continued with a gentle heat, till the oil appears of a proper consistence; in which state it is called varnish. It is necessary to have two kinds of this varnish, a thicker and a thinner, from the greater or less boiling, to be occasionally mixed together, as different purposes may require; that which answers well in hot weather being too thick in cold, and large characters not requiring so stiff an ink as small ones.

The thickest varnish, when cold, may be drawn into threads like weak glue; by which criterion the workmen judge of the due boiling, small quantities being from time to time taken out and dropped upon a tile for this purpose. It is very viscid and tenacious, like the soft resinous juices, or thick turpentine. Neither water nor alcohol dissolves it; but it readily enough mingles with fresh oil, and unites with mucilages into a mass diffusible in water in an emulsive form. Boiling with caustic alkali produces a soapy compound. It is by washing with hot soaplees and a brush that the printers clean their types. The oil loses from one-tenth to one-eighth of its weight by the boiling into the thick varnish.

It is affirmed, that varnish containing either turpentine or litharge, particularly the latter, is more adhesive than other varnish, and presents a great difficulty in cleaning the types, which soon become clogged. Very old oil requires neither of these additions. New oil can hardly be brought into a proper state for drying, so as not to set off, without the use of turpentine.

Lampblack is the common material to give the black colour, of which two ounces and a half are sufficient for sixteen ounces of the varnish. Vermilion is a good red. They are ground together on a stone with a muller, in the same manner as oil paints.

The ink used by copperplate printers differs in the oil, which is not so much boiled as to acquire the adhesive quality. This would render it less disposed to enter the cavities of the engraving, and more difficult either to be spread or wiped off. The black is likewise of a different kind. Instead of lampblack, or sublimed charcoal, the Frankfort black is used, which is a residual or denser charcoal, said to be made from vine-twigs. This is softer and less gritty than the ivory or other blacks prepared among us, and, no doubt, contains more coal than any animal residue, as all these abound with phosphate of lime. It is said, that lampblack gives always a degree of toughness to the ink, which the Frankfort black does not, but the goodness of the colour seems to be the leading inducement for the use of the latter. A pale or brown black can be much more easily endured in a book, than in the impression of an engraving.

We have no good explanation of what happens with regard to the chemical effect of boiling and burning upon the oil for printers' use.

Common ink for writing is made by adding an infusion or decoction of the nut-gall to sulphate of iron, dissolved in water. A very fine black precipitate is thrown down, the speedy subsidence of which is prevented by the addition of a proper quantity of gum-arabic. This is usually accounted for by the superior affinity of the gallic acid, which, combining with the iron, takes it from the sulphuric, and falls down. But it appears as if this were not the simple state of the facts; for the sulphuric acid in ink is not so far disengaged as to act speedily upon fresh iron, or give other manifestations of its presence in an uncombined state. According to Deyeux, the iron in ink is partly in the state of a gallate.

M. Ribaucourt paid particular attention to the process for making black ink, and from his experiments he draws the following inferences:—That logwood is a useful ingredient in ink, because its colouring matter is disposed to unite with the oxide of iron, and renders it not only of a very dark colour, but less capable of change from the action of acids, or of the air. Sulphate of copper, in a certain proportion, gives depth and firmness to the colour of the ink. Gum-arabic, or any other pure gum, is of service, by retarding the precipitation of the feculæ: by preventing the ink from spreading or sinking into the paper; and by affording it a kind of compact varnish, or defence from the air when dry. Sugar appears to have some bad qualities, but is of use in giving a degree of fluidity to the ink, which permits the dose of gum to be enlarged beyond what the ink would bear without it. Water is the best solvent.

Lewis had supposed, that the defects of ink arise chiefly from a want of colouring matter. But the theory, grounded on the fact discovered by M. Ribaucourt, requires that none of the principles should be in excess.

It is doubtful whether the principles of the galls be well extracted by maceration; and it is certain, that inks made in this way flow pale from the pen, and are not of so deep a black as those wherein strong boiling is recurred to.

From all the foregoing considerations M. R. gives these directions for the composition of good ink:—

Take eight ounces of Aleppo galls (in coarse powder;) four ounces of logwood (in thin chips;) four ounces of sulphate of iron; three ounces of gum-arabic (in powder;) one ounce of sulphate of copper; and one ounce of sugar-candy. Boil the galls and logwood together in twelve pounds of water for one hour, or till half the liquid has evaporated. Strain the decoction through a hair sieve, or linen cloth, and then add the other ingredients. Stir the mixture, till the whole is dissolved, more especially the gum; after which, leave it to subside for twenty-four hours. Then decant the ink, and preserve it in bottles of glass or stone ware, well corked.

Many recommend, that the sulphate of iron should be calcined to whiteness. Mr. Desormeaux, jun. an ink manufacturer in Spitalfields, has given the following in the Philosophical Magazine, as the result of much experience:—Boil four ounces of logwood about an hour in six beer quarts of water, adding boiling water from time to time; strain while hot; and when cold add water enough to make the liquor five quarts. Into this put one pound avoirdup. of blue galls coarsely bruised; four ounces of sulphate of iron calcined to whiteness; three ounces of coarse brown sugar; six ounces of gum-arabic; and ½ ounce of acetate of copper, triturated with a little of the decoction to a paste, and then thoroughly mixed with the rest. This is to be kept in a bottle uncorked about a fortnight, shaking it twice a-day, after which it may be poured from the dregs, and corked up for use.

Dr. Lewis uses vinegar for his menstruum; and M. Ribaucourt has sulphate of copper among his ingredients. I have found an inconvenience from the use of either, which, though it does not relate to the goodness of the ink, is sufficiently great, in their practical exhibition, to forbid their use. The acid of the vinegar acts so strongly upon the pen, that it very frequently requires mending; and the sulphate of copper has a still more unpleasant effect on the penknife. It seldom happens when a pen requires mending, that the ink is wiped very perfectly from it; and often, when the nib only is to be taken off, it is done without wiping at all. Whenever this is the case, the ink immediately deposites a film of copper upon the knife, and by superior elective attraction of the sulphuric acid, a correspondent portion of the edge of the knife is dissolved, and is by this means rendered incapable of cutting till it has been again set upon the hone.

If a little sugar be added to ink, a copy of the writing may easily be taken off, by laying a sheet of thin unsized paper, damped with a sponge, on the written paper, and passing lightly over it a flat iron very moderately heated.

Inks of other colours may be made from a strong decoction of the ingredients used in dyeing, mixed with a little alum and gum-arabic. For example, a strong decoction of Brazil wood, with as much alum as it can dissolve, and a little gum, forms a good red ink. These processes consist in forming a lake, and retarding its precipitation by the gum. See Lake.

On many occasions it is of importance to employ an ink indestructible by any process, that will not equally destroy the material on which it is applied. Mr. Close has recommended for this purpose twenty-five grains of copal in powder dissolved in 200 grains of oil of lavender, by the assistance of gentle heat, and then mixed with two and a half grains of lampblack, and half a grain of indigo; or 120 grains of oil of lavender, seventeen grains of copal, and sixty grains of vermilion. A little oil of lavender, or of turpentine, may be added, if the ink be found too thick. Mr. Sheldrake suggests, that a mixture of genuine asphaltum dissolved in oil of turpentine, amber varnish, and lampblack, would be still superior.

When writing with common ink has been effaced by means of aqueous chlorine, the vapour of sulphuret of ammonia, or immersion in water impregnated with this sulphuret, will render it again legible. Or, if the paper that contained the writing be put into a weak solution of prussiate of potash, and, when it is thoroughly wet, a little sulphuric acid be added to the liquor, so as to render it slightly acidulous, the same purpose will be answered.

Mr. Haussman has given some compositions for marking pieces of cotton or linen, previous to their being bleached, which are capable of resisting every operation in the processes both of bleaching and dyeing, and consequently, might be employed in marking linen for domestic purposes. One of these consists of asphaltum dissolved in about four parts of oil of turpentine, and with this is to be mixed lampblack, or black lead in fine powder, so as to make an ink of a proper consistence for printing with types. Another, the blackish sulphate left after expelling oxygen gas from oxide of manganese with a moderate heat, being dissolved and filtered, the dark gray pasty oxide left on the filter is to be mixed with a very little solution of gum-tragacanth, and the cloth marked with this is to be dipped in a solution of potash or soda, mild or caustic, in about ten parts of water.

Among the amusing experiments of the art of chemistry, the exhibition of sympathetic inks holds a distinguished place. With these the writing is invisible, until some reagent gives it opacity. We shall here mention a few out of the great number, that a slight acquaintance with chemistry may suggest to the student. 1. If a weak infusion of galls be used, the writing will be invisible till the paper be moistened with a weak solution of sulphate of iron. It then becomes black, because these ingredients form ink. 2. If paper be soaked in a weak infusion of galls, and dried, a pen dipped in the solution of sulphate of iron will write black on that paper, but colourless on any other paper. 3. The diluted solutions of gold and silver remain colourless upon the paper, till exposed to the sun's light, which gives a dark colour to the oxides, and renders them visible. 4. Most of the acids, or saline solutions, being diluted, and used to write with, become visible by heating before the fire, which concentrates them, and assists their action on the paper. 5. Diluted prussiate of potash affords blue letters when wetted with the solution of sulphate of iron. 6. The solution of cobalt in aqua regia, when diluted, affords an ink which becomes green when held to the fire, but disappears again when suffered to cool. This has been used in fanciful drawings of trees, the green leaves of which appear when warm, and vanish again by cold. If the heat be continued too long after the letters appear, it renders them permanent. 7. If oxide of cobalt be dissolved in acetic acid, and a little nitre added, the solution will exhibit a pale rose colour when heated, which disappears on cooling. 8. A solution of equal parts of sulphate of copper and muriate of ammonia, gives a yellow colour when heated, that disappears when cold.

Sympathetic inks have been proposed as the instruments of secret correspondence. But they are of little use in this respect, because the properties change by a few days remaining on the paper; most of them have more or less of a tinge when thoroughly dry; and none of them resist the test of heating the paper till it begins to be scorched.

* Nitrate of silver for a surface impregnated with carbonate of soda, and muriate of gold for one impregnated with protomuriate of tin, form good indelible inks.*

Insects. Various important products are obtained from insects. The chief are, 1. Cantharides; 2. Millepedes; 3. Cochineal; 4. Kermes; 5. Lac; 6. Silk; 7. Wax.

Instruments (Chemical.) See Balance, Thermometer, Laboratory.

* **Intestinal Concretions.** For a description of such of these as occur in the inferior animals, see Bezoar.

I shall here insert an account of a very curious concretion extracted from the rectum of a woman in Perthshire, in the year 1817. She is, I believe, still alive. It was sent to me by her physician, Dr. Kennedy of Dunning. The following paper was written at the time, and an abstract published in a London Medical Journal, in the autumn of the same year.

The form of the concretion is a compressed cylinder, the length and larger diameter, each one inch; the smaller diameter, three quarters of an inch. In hardness, it is equal to wax, but without its tenacity. One of the ends, which is polished, and glistening, exhibits the appearance of concentric laminæ, formed of circular brown lines, in a yellow basis. Its sides have the lustre, and marbled appearance, of Castile soap. Its internal structure is granular, approaching to crystalline, with radiations from the centre to the circumference, of brown and bright yellow lines, possessed of pearly lustre. It is friable between the fingers, covering them, on pressure, with a mealy powder, of but little unctuosity.

Its weight is 167.5 grains. Specific gravity of the mass seems at first inferior to that of distilled water; for it floats on it for a little, but it afterwards sinks to the bottom. In a solution of muriate of soda, sp. gr. 1.0135, a fragment of it remains suspended in any part of the fluid. This, therefore, is its specific gravity.

Its odour is strong, but by no means disagreeable. It is decidedly musky, or more precisely that of ambergris.

Water has no action on it, nor does it affect the purple of litmus. It remains solid in boiling water. When it is heated to the temperature of about 400° F., it fuses into a black mass, and exhales a copious white smoke, in the odour of which, we may recognize that of ambergris, mixed with the smell of burning fat. Exposed in a platina capsule to a dull red heat, it burns with much flame and smoke, leaving no appreciable residuum.

It dissolves rapidly in sulph. ether, forming an amber-coloured liquid. When the ether evaporates away, white glistening scales, of a micaceous appearance, are left.

Ten parts of hot alcohol dissolve one of it, but as the alcohol cools, the greater part precipitates in these soft crystalline scales, while the surface of the liquid becomes covered with a beautiful iridescent pellicle, presenting stellated radiations

Naphtha, the fixed and volatile oils, readily act upon it, forming bright yellow solutions.

Small fragments of it, exposed on a sand-bath, for two days, in a glass capsule, containing the water of pure potash, were not found to be altered in their size or appearance. Neither does liquid ammonia, digested on it, produce the slightest effect. In these respects, it possesses more analogies with ambergris, than with any other substance I know. I was hence led to imagine that the white smoke which it exhales at a moderate heat, was benzoic acid, which this substance is said copiously to contain.

An alcoholic solution of the concretion was therefore added to water of ammonia, when a milky liquid was produced by the separation of the substance, in a finely divided state. This mixture was evaporated to dryness by a gentle heat, in order to get rid of the alcohol and uncombined ammonia. Warm water was then digested on the residuum, and the whole poured on a filter. The liquid which passed through, should have contained benzoate of ammonia, provided any benzoic acid existed in the concretion. It was divided into two portions. Into one of these, a few drops of dilute sulphuric acid were poured; and the acidulous fluid was then concentrated by evaporation in a glass capsule; but on cooling, it afforded no traces of benzoic acid. An extremely minute quantity of benzoate of ammonia, treated in the same way, for comparison, gave the characteristic crystals of that acid. The other portion. was added to a neutral solution of red muriate of iron, but no precipitate ensued. A very small particle of crystallized benzoate of ammonia being added to the same muriate, speedily gave the brown precipitate, but produced no change whatever on solutions, perfectly neutral, of the *green* muriate and sulphate; a fact of consequence to show the state of oxidizement, in which iron exists in a mineral, or saline combination, indicating also an easy method of separating the two oxides of this metal. From the above experiments, we may infer, with much probability, that the concretion contains no benzoic acid.

Nitric acid, sp. gravity 1.300, digested on it, at a gentle heat, and then cooled, converted the substance into bright yellow globules, denser and less friable than the original matter, and somewhat semi-transparent, like impure rosin. There was, however, no true solution by the acid; nor was the combustibility in the least impaired by the operation.

As our Institution possesses specimens of very fragrant ambergris, said to have been imported in the genuine state from Persia, I was desirous to compare their chemical relations with those of this morbid concretion. Two of the pieces of ambergris differ in many respects from one another. The first is of a light gray colour, with resinous looking points interspersed through it, and has a density considerably greater than water. It is 1.200. When heated in water to the temperature of 130°, it falls down into light spongy fragments. The second has a specific gravity of 0.959; it is darkish brown on the outside, and light brown within. In water heated to the above degree, it softens into a viscid substance like treacle. Both are readily dissolved in warm alcohol, but the latter yields the richer golden-coloured solution. As the alcohol cools, a separation of brilliant scales is perceived. With ether, naphtha, the fixed and volatile oils, the phenomena exhibited by ambergris are absolutely the same, as those presented by the concretion, with these solvents. The alcoholic solution, mixed with liquid ammonia, gives a similar milky emulsion.

The *lighter* specimen of ambergris, exposed to a gentle heat over a lamp, in a glass tube seal. d at one end, fuses and evolves a volatile oil in dense vapour, which is condensed on the upper part of the tube. A viscid substance like tar, remains at the bottom. The oil resembles the succinic, and has, like it, a disagreeable empyreumatic odour. The *denser* ambergris, being subjected to heat in like circumstances, fuses less readily and completely, emits the same volatile empyreumatic oil, accompanied with crystalline needles, decidedly acidulous. These are either the benzoic or succinic acid. They precipitate peroxide of iron from the neutral red muriate. The smell of the accompanying oil, is certainly that of amber; but I have hitherto obtained too small quantities of the acid, to be able to determine to which of the two *it* belongs. The following experiments were made with this view. My first object was to discover a good criterion for discriminating benzoic from succinic acid. In operating necessarily on small quantities, the distinction becomes peculiarly difficult. Both are volatile, crystallizable, and fall down with peroxide of iron, from saline solutions of this metal. After many trials I finally fell on the following plan, which answers very well, even with pretty minute portions. I saturated each acid with ammonia; evaporated to a dry crystalline mass, by a gentle heat. Into a small glass tube, sealed at one end, I introduced a portion of the benzoate. The tube was recurved. I exposed the bottom where the salt was placed, to the heat of a lamp, but very cautiously. Pungent ammoniacal gas was exhaled, and the water of crystallization, that distilled over, was found strongly impregnated with ammonia. To avoid all fallacy in this result, I slightly supersaturated the ammonia beforehand, with the acid. In the middle of the tube, pure benzoic acid was found, in acicular crystals. The succinate of ammonia, on the contrary, sublimes without decomposition.

I now took a few grains of the dense ambergris, digested with alcohol, added water of ammonia, boiled, filtered, and evaporated to dryness. The quantity of saline matter obtained, was, however, too minute, even for the above mode of applying an analytical criterion, with satisfaction; and being unwilling to consume more than a few grains of a specimen, belonging to a public establishment, I preferred waiting till some future opportunity might occur of examining genuine ambergris.

From the lighter, and by its outward appearance, more characteristic specimen, of ambergris, I could not obtain even a trace of benzoic acid, though I modified the temperature for sublimation, and other circumstances, in every way I could think of. The oil that rose would not redden the most delicate litmus paper.

In open capsules, fragments of the ambergris, being exposed to pretty strong heat, exhaled the copious subfœtid smoke; and afterwards burned with the yellow flame, exhibited by the concretion. Fragments of the concretions, exposed to heat in a glass tube, fused, evolved the heavy smoke, which condensed into a viscid empyreumatic smelling oil, and in every respect comported itself like the light ambergris.

I therefore must infer it to be a modification of ambergris. It differs decidedly from the adipocere of dead bodies, which forms an emulsion with cold water, is fusible in boiling water, gives a soap, with evolution of ammonia, when treated with potash, and yields a clear solution, when gently heated with liquid ammonia. It resembles, however, in many respects, the cholesterine of biliary calculi; and I have no doubt that cholesterine from altered bile, is the true origin of ambergris in the whale, as well as of this morbid concretion.

The concretion is almost wholly soluble in hot alcohol; while only one-third of adipocere dissolves in that menstruum at the boiling point.

From ordinary fatty matter it is entirely distinguishable, by its solubility in ether and alcohol, its refusing to combine with alkalis, and the high temperature required for its fusion.

With regard to their place of formation in the animal system, ambergris and this morbid concretion agree. They are both generated in the rectum, or greater intestines. The physeter macrocephalus of Linnæus is the species of whale which affords ambergris. In the examination of Captain Coffin before the Privy-Council in 1791, he stated, that he found 362 ounces of ambergris in the intestines of a female whale, struck off the coast of Guinea; part of it was voided from the rectum on cutting up the blubber, and the remainder was within the intestinal canal.

The whales that contain ambergris are said to be always lean and sickly, yield but very little oil, and seem almost torpid. Hence when a spermaceti whale has this appearance, and does not emit feces on being harpooned, the fishers generally expect to find ambergris within it. Whether it be the cause or the effect of disease, is problematical, though the latter seems the more rational conjecture. It may in succession be both. The above remarkable fact of the sex of the whale, may lead to an inquiry, whether this morbid production, found also in the human subject, be peculiar to females, and connected with lactation.

In the second volume of Dr. Monro's Outlines of the Anatomy of the Human

Body in its sound and diseased state, we have the analysis of several alvine concretions by Dr. Thomas Thomson. The results, obtained by this eminent chemist, show, that the specimens which he examined, were of a totally different nature from the preceding concretion.*

* **Inulin.** From the root of the *inula helenium*, or elecampane, Rose first extracted the peculiar vegetable principle, called inulin. M. Funke has since given the following as the analysis of elecampane root:—

A crystallizable volatile oil,
Inulin,
Extractive,
Acetic acid,
A crystallizable resin,
Gluten,
A fibrous matter (ligneous).*

* **Iodine.** A peculiar or undecompounded principle. The investigation of this singular substance will always be regarded as a great era in chemistry. It was then that chemical philosophers first felt the necessity of abandoning Lavoisier's partial and incorrect hypothesis of oxygenation, and of embracing the sound and comprehensive doctrines of Sir H. Davy on chemical theory, first promulgated in his masterly researches on *Chlorine*.

Iodine was accidentally discovered, in 1812, by M. de Courtois, a manufacturer of saltpetre at Paris. In his processes for procuring soda from the ashes of sea-weeds, he found the metallic vessels much corroded; and in searching for the cause of the corrosion, he made this important discovery. But for this circumstance, nearly accidental, one of the most curious of substances might have remained for ages unknown, since nature has not distributed it, in either a simple or compound state, through her different kingdoms, but has confined it, to what the Roman satirist considers as the most worthless of things, the vile sea-weed.

Iodine derived its first illustration from MM. Clement and Desormes, names associated always with sound research. In their memoir, read at a meeting of the Institute, these able chemists described its principal properties. They stated its sp. gr. to be about 4; that it becomes a violet-coloured gas at a temperature below that of boiling water; whence its name, Ἰωδης; *like a violet*, was derived; that it combines with the metals, and with phosphorus and sulphur, and likewise with the alkalis and metallic oxides; that it forms a detonating compound with ammonia; that it is soluble in alcohol, and still more soluble in ether; and that, by its action upon phosphorus and upon hydrogen, a substance having the characters of muriatic acid is formed. In this communication they offered no decided opinion respecting its nature.

In 1813 Sir H. Davy happened to be on a visit to Paris, receiving, amid the political convulsions of France, the tranquil homage due to his genius. "When M. Clement showed iodine to me, he believed that the hydriodic acid was muriatic acid; and M. Gay-Lussac, after his early experiments, made originally with M. Clement, formed the same opinion, and *maintained* it, when I *first* stated to him my belief, that it was a new and peculiar acid, and that iodine was a substance analogous in its chemical relations to chlorine."—*Sir H. Davy on the Analogies between the undecompounded substances; Journal of Science and the Arts*, vol. i. p. 284.

We see therefore with what intuitive sagacity the English philosopher penetrated the mystery which hung at first over iodine. Its full examination, in its multiplied relations to simple and compound bodies, was immediately entered on with equal ardour by him, and M. Gay-Lussac. Of the relative merits of the researches, and importance of the results, of these pre-eminent chemists, it is not for me to become an arbiter. I shall content myself with offering a methodical view of the facts brought to light on iodine and the iodides, referring for its other combinations to what I have already stated on the hydriodic and iodic acids.

Iodine has been found in the following sea-weeds, the algæ aquaticæ of Linnæus:—

Fucus cartilagineus;
membranaceus,
filamentosus,
rubens,
nodosus,
serratus,
siliquosus,
Fucus palmatus,
filum,
digitatus,
saccharinus,
Ulva umbilicalis,
pavonia,
linza, and in
sponge.

Dr. Fyfe has shown, in an ingenious paper, published in the first volume of the Edin. Phil. Journal, that on adding sulphuric acid to a concentrated viscid infusion of these algæ in hot water, the vapour of iodine is exhaled.

But it is from the incinerated sea-weed, or kelp, that iodine in quantities is to be obtained. Dr. Wollaston first communicated a precise formula for extracting it. Dissolve the soluble part of kelp in water. Concentrate the liquid by evaporation, and separate all the crystals that can be obtained. Pour the remaining liquid into a clean vessel, and mix with it an excess of sulphuric acid. Boil this liquid for some time. Sulphur is precipitated, and muriatic acid driven off. Decant off the clear liquid, and strain it through wool. Put it into a small flask, and mix it with as much black oxide of manganese, as used before of sulphuric acid. Apply to the top of the flask a glass tube, shut at one end. Then heat the mixture in the flask. The iodine sublimes into the glass tube. None can be obtained from sea-water.

In repeating this process with care, I obtained from similar quantities of kelp such variable products of iodine, that I was induced to institute a series of experiments in 1814, for discovering the causes of these anomalies, and for procuring iodine at an easier rate. The result, which was successful, I communicated to the world in the 50th volume of the Philosophical Magazine. Instead of procuring this interesting element in only a few grains, I have been able to extract ounces at a time, and at a moderate expense. I shall here transcribe the outlines of my method.

As several of the Scotch soap manufacturers use scarcely any other alkaline matter for their hard soaps except kelp, it occurred to me that in some of their residuums, a substance might be found rich in iodine. Accordingly, after some investigation, I found a brown liquid, of an oily consistence, from which I expected to procure what I wanted, and I therefore instituted a series of experiments on the best mode of extraction.

The specific gravity of this liquid, as obtained at different times, is pretty uniformly 1.374. It converts vegetable blues to green, thus indicating free alkali. Of this the manufacturer is aware, for he returns the liquid occasionally into his kelp leys. Its boiling point is 233° F. Eight ounces apothecaries' measure require precisely one measured ounce of sulphuric acid for their neutralization. Supposing this quantity of acid combined with soda, it would indicate one part of pure soda in eleven by weight of the liquid. But the chief part of the alkali is not uncombined; for an immense quantity of sulphurous acid, and a little sulphuretted hydrogen gas, escape during the affusion of the sulphuric acid.

"100 grains of the liquid yield 3.8 cubic inches of gas, chiefly sulphurous acid, and sulphur is at the same time deposited. From this last circumstance one would expect a greater proportion of sulphuretted hydrogen; but the disengaged gas possesses the peculiar smell and pungency of burning sulphur, blanches the petals of the red rose, but shows scarcely any action on paper dipped in saturnine solutions. On the instant of decomposition of the sulphite and hydroguretted sulphuret of soda existing in the liquid, the nascent sulphurous acid of the former may be supposed to decompose the nascent sulphuretted hydrogen of the latter; their atoms of oxygen and hydrogen uniting, with precipitation of the sulphur. I can in no other way account for the very copious separation of sulphur, while very little sulphuretted hydrogen appears." I now find the liquid to contain hyposulphite of soda.

From 8 liquid ounces = 11 by weight, 213 grains of sulphur are obtained. The saturated liquid has a specific gravity of 1.443, a bright yellow colour, and does not change the purple colour of infusion of red cabbage.

Having described the substance which I used, I shall now state, in a few words, the best method of taking the iodine out of it:—

"The brown iodic liquid of the soap-boiler, was heated to about 230° F. poured into a large stone-ware basin, of which it filled about one-half, and saturated by the addition of the suitable quantity of sulphuric acid as above stated. It is advantageous to dilute the acid previously, with its own bulk of water.§ On cooling the mixture, a large quantity of saline crystals is found adhering to the sides and bottom of the vessel. These are chiefly, sulphate of soda, with a very little sulphate of potash and a few beautiful oblong rhomboidal plates of hydriodate of soda. Sulphur is mixed with these crystals.

"Filter the above cold liquid through woollen cloth. To every 12 oz. apothecaries' measure, add 1000 grains of black oxide of manganese in powder. Put this mixture into a glass globe, or large matrass with a wide neck, over which a glass globe is inverted, and apply heat with a charcoal chauffer. The less diffusive flame of a lamp, is apt to crack the bottom of the matrass; particularly, if a large quantity of materials be employed. To prevent the heat from acting on the globular receiver, a thin disc of wood, having a round hole in its centre, is placed over the shoulder of the matrass.

"Iodine now sublimes very copiously, and is readily condensed in the upper vessel. As soon as this becomes warm, another is to be put in its place; and thus the two may be applied in rotation, as long as the violet vapour rises.

"From the above quantity of liquid, by this treatment, I obtain from 180 to 200 grains of iodine, perfectly pure. It is withdrawn from the globes, most conveniently by a little water, which dissolves iodine very sparingly, as is well known. It may be purified by a second sublimation from lime.

"If the manganese be increased much beyond the above proportion, the product of iodine is greatly decreased. If thrice the quantity be used, for example, a furious effervescence takes place, nearly the whole mixture is thrown out of the matrass, with a kind of explosive violence, and hardly any iodine is procured, even though the materials should be saved, by the relatively large capacity of the vessel that contains them. If, on the other hand, one-half of the prescribed quantity of manganese be used, much hydriodic acid rises along with the iodine, and washes it perpetually down the sides of the balloon. Or if, during the proper and successful sublimation of iodine, the weight of manganese be doubled, the violet vapours instantly cease. Nor will sugar or starch restore to the mixture, the power of exhaling the iodine.

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§ When concentrated acid is added, the effervescence is very violent; the liquid reddens wherever the acid falls, and a little purple vapour of iodine rises.

"The same interruption of the process is occasioned by using an excess of sulphuric acid. For, if to the mixture of 12 oz. of saturated liquid, with 1000 or 1100 grains manganese, an additional half ounce measure of sulphuric acid be poured in, the violet vapour disappears, and the sublimation of iodine is at an end. Quicklime now added so as to saturate the excess of acid, will not restore the production of iodine.

"The best subliming temperature is 232° Fahr.

"Iodine, in open vessels, readily evaporates at much lower temperatures, even at the usual atmospheric heats. When it is spread thin on a plate of glass, if the eye be placed in the same plane, the violet vapour becomes very obvious at the temperature of 100° F. If left in the open air, it will speedily evaporate altogether away, even at 50 or 60°. When kept in a phial stopped with a common cork, the iodine also disappears, while the cork will become friable in its texture, and of a brownish-yellow colour.

"240 grains of nitric acid, specific grav. 1.490, saturate 1000 grains of the brown liquid. Sulphurous acid is abundantly exhaled as before. After filtration, a bright golden-coloured liquid is obtained. On adding to this liquid a little manganese, iodine sublimes; but the quantity procurable in this way, seems to be proportionally less than by the sulphuric acid."

I have described a new form of apparatus, for sublimation, in the above paper, by which beautiful crystals may easily be procured, without risk of injuring their form.

Iodine is a solid, of a grayish-black colour and metallic lustre. It is often in scales similar to those of micaceous iron ore, sometimes in rhomboidal plates, very large and very brilliant. It has been obtained in elongated octohedrons, nearly half an inch in length; the axes of which were shown by Dr. Wollaston to be to each other, as the numbers 2, 3, and 4, at least so nearly, that in a body so volatile, it is scarcely possible to detect an error in this estimate, by the reflective goniometer. Its fracture is lamellated, and it is soft and friable to the touch. Its taste is very acrid, though it be very sparingly soluble in water. It is a deadly poison. It gives a deep brown stain to the skin, which soon vanishes by evaporation. In odour, and power of destroying vegetable colours, it resembles very dilute aqueous chlorine. The sp. gr. of iodine at 62½° is 4.948. It dissolves in 7000 parts of water. The solution is of an orange-yellow colour, and in small quantity tinges raw starch of a purple hue, which vanishes on heating it. It melts, according to M. Gay-Lussac, at 227° F. and is volatilized under the common pressure of the atmosphere, at the temperature of 350°. By my experiments, it evaporates pretty quickly at ordinary temperatures. Boiling water aids its sublimation, as is shown in the above process of extraction. The sp. gr. of its violet vapour is 8.678. It is a non-conductor of electricity. When the voltaic chain is interrupted by a small fragment of it, the decomposition of water instantly ceases.

Iodine is incombustible, but with azote it forms a curious detonating compound; and in combining with several bodies, the intensity of mutual action is such as to produce the phenomena of combustion. Its combinations with oxygen and chlorine, have been already described, under iodic and chloriodic acids.

With a view of determining whether it was a simple or compound form of matter, Sir H. Davy exposed it to the action of the highly inflammable metals. When its vapour is passed over potassium heated in a glass tube, inflammation takes place, and the potassium burns slowly with a pale blue light. There was no gas disengaged when the experiment was repeated in a mercurial apparatus. The iodide of potassium is white, fusible at a red heat, and soluble in water. It has a peculiar acrid taste. When acted on by sulphuric acid, it effervesces, and iodine appears. It is evident, that in this experiment there had been no decomposition; the result depending merely on the combination of iodine with potassium. By passing the vapour of iodine over dry red-hot potash, formed from potassium, oxygen is expelled, and the above iodide results. Hence we see, that at the temperature of ignition, the affinity between iodine and potassium, is superior to that of the latter for oxygen. But iodine in its turn is displaced by chlorine, at a moderate heat, and if the latter be in excess, chloriodic acid is formed. M. Gay-Lussac passed vapour of iodine in a red heat over melted subcarbonate of potash; and he obtained carbonic acid and oxygen gases, in the proportions of two in volume of the first, and one of the second, precisely those which exist in the salt.

The oxide of sodium, and the subcarbonate of soda, are also completely decomposed by iodine. From these experiments it would seem, that this substance ought to disengage oxygen, from most of the oxides; but this happens only in a small number of cases. The protoxides of lead and bismuth are the only oxides not reducible by mere heat, with which it exhibited that power. Barytes, strontian, and lime combine with iodine, without giving out oxygen gas, and the oxides of zinc and iron undergo no alteration in this respect. From these facts we must conclude, that the decomposition of the oxides by iodine depends less on the condensed state of the oxygen, than upon the affinity of the metal for iodine. Except barytes, strontian, and lime, no oxide can remain in combination with iodine at a red heat. For a more particular account of some iodides, see Acid (Hydriodic); the compounds of which, in the liquid or moist state, are hydriodates, but change, on drying, into iodides, in the same way as the muriates become chlorides.

From the proportion of the constituents in hydriodic acid, 15.5 has been deduced, as the prime equivalent of iodine.

M. Gay-Lussac says, "Sulphate of potash was not altered by iodine; but, what may appear astonishing, I obtained oxygen with the fluate of potash, and the glass tube in which the operation was conducted was corroded. On examining the circumstances of the experiment, I ascertained that the fluate became alkaline when melted in a platinum crucible. This happened to the fluate over which I passed iodine. It appears then that the iodine acts upon the excess of alkali, and decomposes it. The heat produced disengages a new portion of fluoric acid or its radical, which corrodes the glass; and thus by degrees the fluate is entirely decomposed." These facts seem to give countenance to the opinion, that the fluoric is an oxygen acid; and that the salt called fluate of potash is not a fluoride of potassium. See Acid (Fluoric).

Iodine forms with sulphur a feeble compound, of a grayish-black colour, radiated like sulphuret of antimony. When it is distilled with water, iodine separates.

Iodine and phosphorus combine with great rapidity at common temperatures, producing heat without light. From the presence of a little moisture, small quantities of hydriodic acid gas are exhaled.

Oxygen expels iodine from both sulphur and phosphorus.

"Hydrogen, whether dry or moist, did not seem," says M. Gay-Lussac, "to have any action on iodine at the ordinary temperature; but if, as was done by M. Clement, in an experiment at which I was present, we expose a mixture of hydrogen and iodine to a red heat in a tube, they unite together, and hydriodic acid is produced, which gives a reddish-brown colour to water." Sir H. Davy, with his characteristic ingenuity, threw the violet-coloured gas upon the flame of hydrogen, when it seemed to support its combustion. He also formed a compound of iodine with hydrogen, by heating to redness the two bodies in a glass tube. See Acid (Hydriodic).

Charcoal has no action upon iodine, either at a high or low temperature. Several of the common metals, on the contrary, as zinc, iron, tin, mercury, attack it readily, even at a low temperature, provided they be in a divided state. Though these combinations take place rapidly, they produce but little heat, and but rarely any light.

The compound of iodine and zinc, or iodide of zinc, is white. It melts readily, and is sublimed in the state of fine acicular four-sided prisms. It is very soluble in water, and rapidly deliquesces in the air. It dissolves in water, without the evolution of any gas. The solution is slightly acid, and does not crystallize. The alkalis precipitate from it white oxide of zinc; while concentrated sulphuric acid disengages hydriodic acid and iodine, because sulphurous acid is produced. The solution is a hydriodate of oxide of zinc. When iodine and zinc are made to act on each other under water in vessels hermetically sealed, on the application of a slight heat, the water assumes a deep reddish-brown colour, because, as soon as hydriodic acid is produced, it dissolves iodine in abundance. But by degrees, the zinc, supposed to be in excess, combines with the whole iodine, and the solution becomes colourless like water.

Iron is acted on by iodine in the same way as zinc; and a brown iodide results, which is fusible at a red heat. It dissolves in water, forming a light green solution, like that of muriate of iron. When the dry iodide was heated, by Sir H. Davy, in a small retort containing pure ammoniacal gas, it combined with the ammonia, and formed a compound which volatilized without leaving any oxide.

The iodide of tin is very fusible. When in powder, its colour is a dirty orange-yellow, not unlike that of glass of antimony. When put into a considerable quantity of water, it is completely decomposed. Hydriodic acid is formed, which remains in solution in the water, and the oxide of tin precipitates in white flocculi. If the quantity of water be small, the acid being more concentrated, retains a portion of oxide of tin, and forms a silky orange-coloured salt, which may be almost entirely decomposed by water. Iodine and tin act very well on each other, in water of the temperature of

212°. By employing an excess of tin, we may obtain pure hydriodic acid, or at least an acid containing only traces of the metal. The tin must be in considerable quantity, because the oxide which precipitates on its surface, diminishes very much its action on iodine.

Antimony presents, with iodine, the same phenomena as tin; so that we might employ either for the preparation of hydriodic acid, if we were not acquainted with preferable methods.

The iodides of lead, copper, bismuth, silver, and mercury, are insoluble in water, while the iodides of the very oxidizable metals are soluble in that liquid. If we mix a hydriodate with the metallic solutions, all the metals which do not decompose water will give precipitates, while those which decompose that liquid, will give none. This is at least the case with the above mentioned metals.

There are two iodides of mercury; the one yellow, the other red; both are fusible and volatile. The yellow or protiodide, contains one-half less iodine than the deutiodide. The latter, when crystallized, is a bright crimson. In general there ought to be for each metal as many iodides, as there are oxides and chlorides. All the iodides are decomposed by concentrated sulphuric and nitric acids. The metal is converted into an oxide, and iodine is disengaged. They are likewise decomposed by oxygen at a red heat, if we except the iodides of potassium, sodium, lead, and bismuth Chlorine likewise separates iodine from all the iodides; but iodine, on the other hand, decomposes most of the sulphurets and phosphurets.

When iodine and oxides act upon each other in contact with water, very different results take place, from those above described. The water is decomposed; its hydrogen unites with iodine, to form hydriodic acid; while its oxygen, on the other hand, produces with iodine, iodic acid. All the oxides, however, do not give the same results. We obtain them only with potash, soda, barytes, strontian, lime, and magnesia. The oxide of zinc, precipitated by ammonia from its solution in sulphuric acid, and well washed, gives no trace of iodate and hydriodate.

We shall treat of the compound of iodine and azote under the article NITROGEN.

From all the above recited facts, we are warranted in concluding iodine to be *an undecompounded body*. In its specific gravity, lustre, and magnitude of its prime equivalent, it resembles the metals; but in all its chemical agencies, it is analogous to oxygen and chlorine. It is a non-conductor of electricity, and possesses, like these two bodies, the negative electrical energy with regard to metals, inflammable and alkaline substances; and hence, when combined with these substances in aqueous solution, and electrized in the voltaic circuit, it separates at the positive surface. But it has a positive energy with respect to chlorine; for when united to chlorine, in the chloriodic acid, it separates at the negative surface. This likewise corresponds with their relative attractive energy, since chlorine expels iodine from all its combinations. Iodine dissolves in carburet of sulphur, giving, in very minute quantities, a fine amethystine tint to the liquid.

Iodide of mercury has been proposed for a pigment; in other respects, iodine has not been applied to any purpose of common life. M. Orfila swallowed 6 grains of iodine; and was immediately affected with heat, constriction of the throat, nausea, eructation, salivation, and cardialgia. In ten minutes he had copious bilious vomitings, and slight colic pains. His pulse rose from 70 to about 90 beats in the minute. By swallowing large quantities of mucilage, and emollient clysters, he recovered, and felt nothing next day but slight fatigue. About 70 or 80 grains proved a fatal dose to dogs. They usually died on the fourth or fifth day.*

IRIDIUM. Mr. Tennant, on examining the black powder left after dissolving platina, which from its appearance had been supposed to consist chiefly of plumbago, found it contained two distinct metals, never before noticed, which he has named iridium and osmium. The former of these was observed soon after by Descostils, and by Vauquelin.

To analyze the black powder, Mr. Tennant put it into a silver crucible, with a large proportion of pure dry soda, and kept it in a red heat for some time. The alkali being then dissolved in water, it had acquired a deep orange or brownish-yellow colour, but much of the powder remained undissolved. This, digested in muriatic acid, gave a dark blue solution, which afterwards became of a dusky olive-green; and finally, by continuing the heat, of a deep red. The residuum being treated as before with alkali, and so on alternately, the whole appeared capable of solution. As some silex continued to be taken up by the alkali, till the whole of the metal was dissolved, it seems to have been chemically combined with it. The alkaline solution contains oxide of osmium, with a small proportion of iridium, which separates spontaneously in dark-coloured thin flakes by keeping it some weeks.

The acid solution contains likewise both the metals, but chiefly iridium. By slow evaporation, it affords an imperfectly crystallized mass; which, being dried on blotting-paper, and dissolved in water, gives by evaporation distinct octohedral crystals.

These crystals, dissolved in water, produce a deep red solution, inclining to orange, Infusion of galls occasions no precipitate. but instantly renders the solution almost colourless. Muriate of tin, carbonate of soda, and prussiate of potash, produce nearly the same effect. Ammonia precipitates the oxide, but, possibly from being in excess, retains a part in solution, acquiring a purple colour. The fixed alkalis precipitate the greater part of the oxide, but retain a part in solution, this becoming yellow. All the metals that Mr. Tennant tried, except gold and platina, produced a dark or black precipitate from the muriatic solution, and left it colourless.

The iridium may be obtained pure, by exposing the octohedral crystals to heat, which expels the oxygen and muriatic acid. It was white, and could not be melted by any heat Mr. Tennant could employ. It did not combine with sulphur, or with arsenic. Lead unites with it easily, but is separated by cupellation, leaving the iridium on the cupel as a coarse black powder. Copper forms with it a very malleable alloy, which, after cupellation, with the addition of lead, leaves a small proportion of the iridium, but much less than in the preceding instance. Silver forms with it a perfectly malleable compound, the surface of which is tarnished merely by cupellation; yet the iridium appears to be diffused through it in fine powder only. Gold remains malleable, and little altered in colour, though alloyed with a considerable proportion; nor is it separable either by cupellation or quartation. If the gold or silver be dissolved, the iridium is left as a black powder.

The French chemists observed, that this new metal gave a red colour to the triple salt of platina and sal ammoniac, was not altered by muriate of tin, and was precipitated of a dark brown by caustic alkali. Vauquelin added, that it was precipitated by galls, and by prussiate of potash; but Mr. Tennant ascribes this to some impurity.

Mr. Tennant gave it the name of iridium, from the striking variety of colours it affords while dissolving in muriatic acid.

Dr. Wollaston has observed, that among the grains of crude platina, there are some scarcely distinguishable from the rest but by their insolubility in nitro-muriatic acid. They are harder, however, when tried by the file; not in the least malleable; and of the specific gravity of 19.5. These appeared to him to be an ore, consisting entirely of two new metals.

* Vauquelin has since succeeded in forming sulphuret of iridium, by heating a mixture of ammonia-muriate of iridium and sulphur. It is a black powder consisting of 100 iridium + 33.3 sulphur; whence, supposing it a neutral compound, the prime equivalent of iridium would be 6.0. The same chemist has also alloyed iridium with lead, copper, and tin. They are all malleable; and considerably hardened by the presence of the iridium.*

Iron is a metal of a bluish-white colour, of considerable hardness and elasticity; very malleable, and exceedingly tenacious and ductile. This metal is easily oxidized. A piece of iron wire, immersed in a jar of oxygen gas, being ignited at one end, will be entirely consumed by the successive combustion of its parts. It requires a very intense heat to fuse it; on which account it can only be brought into the shape of tools and utensils by hammering. This high degree of infusibility would deprive it of the most valuable property of metals, namely, the uniting of smaller masses into one, if it did not possess another singular and advantageous property, which is found in no other metal except platina; namely, that of welding. In a white heat, iron appears as if covered with a kind of varnish; and in this state, if two pieces be applied together, they will adhere, and may be perfectly united by forging.

When iron is exposed to the action of moist air or water, it acquires weight by gradual oxidation, and hydrogen gas escapes: this is a very slow operation. But if the steam of water be made to pass through a red-hot gun barrel, or through an ignited copper or glass tube, containing iron wire, the iron becomes converted into an oxide, while hydrogen gas passes out at the other end of the barrel. By the action of stronger heat this becomes a reddish-brown oxide. The yellow rust, formed when iron is long exposed to damp air, is not a simple oxide, as it contains a portion of carbonic acid.

The concentrated sulphuric acid scarcely acts on iron, unless it is boiling. If the acid be diluted with two or three parts of water, it dissolves iron readily, without the assistance of heat. During this solution, hydrogen gas escapes in large quantities.

The green sulphate of iron is much more soluble in hot than cold water; and therefore crystallizes by cooling, as well as by evaporation. The crystals are efflorescent and fall into a white powder by exposure to a dry air, the iron becoming more oxidized than before. A solution of sulphate of iron, exposed to the air, imbibes oxygen; and a portion of the iron, becoming peroxidized, falls to the bottom.

Sulphate of iron is not made in the direct way, because it can be obtained at less charge from the decomposition of martial pyrites. It exists in two states, one containing oxide of iron, with 0.22 of oxygen, which is of a pale green, not altered by gallic acid, and giving a white precipitate with prussiate of potash. The other, in which the iron is combined with 0.30 of oxygen, is red, not crystallizable, and gives a black precipitate with gallic acid, and a blue with prussiate of potash. In the common sulphate, these two are often mixed in various proportions.

Sulphate of iron is decomposed by alkalis and by lime. Caustic fixed alkali precipitates the iron in deep green flocks, which are dissolved by the addition of more alkali, and form a red tincture.

Vegetable astringent matters, such as nut-galls, the husks of nuts, logwood, tea, &c. which contain tannin and gallic acid, precipitate a fine black fecula from sulphate of iron, which remains suspended for a considerable time in the fluid, by the addition of gum-arabic. This fluid is well known by the name of ink. See INK.

The beautiful pigment, well known in the arts by the name of prussian blue, is likewise a precipitate afforded by sulphate of iron.

Concentrated nitric acid acts very strongly upon iron filings, much nitrous gas being disengaged at the same time. The solution is of a reddish-brown, and deposites the oxide of iron after a certain time; more especially if the vessel be left exposed to the air. A diluted nitric acid affords a more permanent solution of iron of a greenish colour, or sometimes of a yellow colour. Neither of the solutions affords crystals, but both deposite the oxide of iron by boiling, at the same time that the fluid assumes a gelatinous appearance.

Diluted muriatic acid rapidly dissolves iron at the same time that a large quantity of hydrogen is disengaged, and the mixture becomes hot.

If iron filings be triturated with muriate of ammonia, moistening the mixture; then drying, powdering, and again triturating; and lastly subliming with a heat quickly raised; yellow or orange-coloured flowers will rise, consisting of a mixture of muriate of ammonia, with more or less muriate of iron. These, which were called *flowers of steel*, and still more improperly *ens veneris*, were once much esteemed; but are now little used, as they are nauseous in solution, and cannot very conveniently be given in any other form.

Carbonic acid, dissolved in water, combines with a considerable quantity of iron, in proportion to its mass.

Phosphoric acid unites with iron, but very slowly. The union is best effected by adding an alkaline phosphate to a solution of one of the salts of iron, when it will fall down in a white precipitate. This acid is found combined with iron in the bog ores, and being at first taken for a peculiar metal, was called *siderite* by Bergmann.

Liquid fluoric acid attacks iron with violence; the solution is not crystallizable, but thickens to a jelly, which may be rendered solid by continuing the heat. The acid may be expelled by heating it strongly, leaving a fine red oxide.

Borate of iron may be obtained by precipitating a solution of the sulphate with neutral borate of soda.

Arsenic acid likewise unites with iron. This arseniate is found native.

Chromate of iron has been found in the department of Var in France, and elsewhere.

Sulphur combines very readily with iron. A mixture of iron filings and flowers of sulphur being moistened, or made into a paste, with water, becomes hot, swells, adheres together, breaks, and emits watery vapours of an hepatic smell. If the mixture be considerable in quantity, as for example, one hundred pounds, it takes fire in twenty or thirty hours, as soon as the aqueous vapours cease.

By fusion with iron, sulphur produces a compound of the same nature as the pyrites, and exhibiting the same radiated structure when broken. If a bar of iron be heated to whiteness, and then touched with a roll of sulphur, the two substances combine, and drop down together in a fluid state. Mr. Hatchett found, that the magnetical pyrites contains the same proportion as the artificial sulphuret.

Phosphorus may be combined with iron by adding it, cut into small pieces, to fine iron wire heated moderately red in a crucible; or by fusing six parts of iron clippings, with six of glacial phosphoric acid, and one of charcoal powder. This phosphuret is magnetic; and Mr. Hatchett remarks, that iron, which in its soft or pure state cannot retain magnetism, is enabled to do so, when hardened by carbon, sulphur, or phosphorus, unless the dose be so great as to destroy the magnetic property, as in most of the natural pyrites and plumbago.

The combination of carbon with iron is of all the most important, and under the names of Cast-Iron and Steel will be considered in the latter part of the present article.

Iron unites with gold, silver, and platina. When heated to a white heat, and plunged in mercury, it becomes covered with a coating of that metal. Mr. A. Aitken unites an amalgam of zinc and mercury with iron filings, and then adds muriate of iron, when a a decomposition takes place, the muriatic acid combining with the zinc, and the amalgam of iron and mercury assuming the metallic lustre by kneading, assisted with heat. Iron and tin very readily unite together. Iron does not unite easily with bismuth, at least in the direct way. This alloy is brittle and attractible by the magkel, even with three-fourths of bismuth. As nickel cannot be purified from iron without the greatest difficulty, it may be presumed, that these substances readily unite. Arsenic forms a brittle substance in its combination with iron. Cobalt forms a hard mixture with iron, which is not easily broken. Manganese is almost always united with iron in the native state. Tungsten forms a brittle, whitish-brown, hard alloy, of a compact texture, when fused with white crude iron. The habitudes of iron with molybdena are not known.

Iron is the most diffused, and the most abundant of metallic substances. Few mineral bodies or stones are without an admixture of this metal. Sands, clays, the waters of rivers and springs, are scarcely ever perfectly free from it. The parts of animal and vegetable substances likewise afford iron in the residues they leave after incineration. It has been found native, in large masses, in Siberia, and in the internal parts of South America. This metal, however, in its native state is scarce: most iron is found in the state of oxide, in ochres, bog ores, and other friable earthy substances, of a red, brown, yellow, or black colour. The magnet or loadstone, is an iron ore. Iron is also found in combination with the sulphuric acid, either dissolved in water, or in the form of sulphate.

In the large iron-works, it is usual to roast or calcine the ores of iron, previous to their fusion; as well for the purpose of expelling sulphureous or arsenical parts, as to render them more easily broken into fragments of a convenient size for melting. The mineral is melted or run down, in large furnaces, from 16 to 30 feet high; and variously shaped, either conical or elliptical, according to the opinion of the iron-master. Near the bottom of the furnace is an aperture for the insertion of the pipe of large bellows, worked by water or steam, or of other machines for producing a current of air; and there are also holes at proper parts of the edifice, to be occasionally opened, to permit the scoriæ and the metal to flow out, as the process may require. Charcoal or coak, with lighted brushwood, is first thrown in; and when the whole inside of the furnace has acquired a strong ignition, the ore is thrown in by small quantities at a time, with more of the fuel, and commonly a portion of limestone, as a flux; the ore gradually subsides into the hottest part of the furnace, where it becomes fused; the earthy part being converted into a kind of glass; while the metallic part is reduced by the coal, and falls through the vitreous matter to the lowest place. The quantity of fuel, the additions, and the heat, must be regulated, in order to obtain iron of any desired quality; and this quality must likewise, in the first product, be necessarily different, according to the nature of the parts which compose the ore.

The iron which is obtained from the smelting furnaces is not pure; and may be distinguished into three states: white crude iron, which is brilliant in its fracture, and exhibits a crystallized texture, more brittle than the other kinds, not at all malleable, and so hard as perfectly to withstand the file: gray crude iron, which exhibits a granulated and dull texture when broken; this substance is not so hard and brittle as the former, and is used in the fabrication of artillery and other articles which require to be bored, turned or repaired: and black cast-iron, which is still rougher in its fracture; its parts adhere together less perfectly than those of the gray crude iron.

In order to convert it into malleable iron, it is placed on a hearth, in the midst of charcoal, urged by the wind of two pair of bellows. As soon as it becomes fused, a workman continually stirs it with a long iron instrument. During the course of several hours it becomes gradually less fusible, and assumes the consistence of paste. In this state it is carried to a large hammer, the repeated blows of which drive out all the parts that still partake of the nature of crude iron so much as to retain the fluid state. By repeated heating and hammering, more of the fusible iron is forced out; and the remainder, being malleable, is formed into a bar or other form for sale. Crude iron loses upwards of one-fourth of its weight in the process of refining; sometimes indeed one-half.

Purified or bar iron is soft, ductile, flexible, malleable, and possesses all the qualities which have been enumerated under this article as belonging exclusively to iron. When a bar of iron is broken, its texture appears fibrous; a property which depends upon the mechanical action of the hammer, while the metal is cold. Ignition destroys this fibrous texture, and renders the iron more uniform throughout; but hammering restores it.

If the purest malleable iron be bedded in pounded charcoal, in a covered crucible, and kept for a certain number of hours in a strong red heat, (which time must be longer or shorter, according to the greater or less thickness of the bars of iron), it is found, that by this operation, which is called cementation, the iron has gained a small addition of weight, amounting to about the hundred and fiftieth, or the two-hundredth part; and is remarkably changed in its properties. It is much more brittle and fusible than before. Its surface is commonly blistered, when it comes out of the crucible; and it requires to be forged, to bring its parts together into a firm and continuous state. This cemented iron is called steel. It may be welded like bar iron, if it have not been fused, or over-cemented; but its most useful and advantageous property is that of becoming extremely hard when ignited and plunged into cold water. The hardness produced is greater in proportion as the steel is hotter, and the water colder. The colours which appear on the surface of steel slowly heated are yellowish-white, yellow, gold colour, purple, violet, deep blue, yellowish-white; after which the ignition takes place. These signs direct the artist in tempering or reducing the hardness of steel to any determinate standard. If steel be too hard, it will not be proper for tools which are intended to have a fine edge, because it will be so brittle, that the edge will soon become notched; if it be too soft, it is evident, that the edge will bend or turn. Some artists ignite their tools, and plunge them into cold water: after which, they brighten the surface of the steel upon a stone: the tool being then laid upon charcoal, or upon the surface of melted lead, or placed in the flame of a candle, gradually acquires the desired colour; at which instant they plunge it into water. If a hard temper be desired, the piece is dipped again, and stirred about in the cold water, as soon as the yellow tinge appears. If the purple appear before the dipping, the temper will be fit for gravers, and tools used in working upon metals; if dipped while blue, it will be proper for springs, and for instruments used in the cutting of soft substances, such as cork, leather, and the like; but if the last pale colour be waited for, the hardness of the steel will scarcely exceed that of iron. When soft steel is heated to any one of these colours, and then plunged into water, it does not acquire nearly so great a degree of hardness, as if previously made quite hard, and then reduced by tempering. The degree of ignition required to harden steel is different in the different kinds. The best kinds require only a low red heat. The harder the steel, the more coarse and granulated its fracture will be; and as this is not completely remedied by the subsequent tempering, it is adviseable to employ the least heat capable of affording the requisite hardness.

The usual time required for the cementation of steel is from six to ten hours. If the cementation be continued too long, the steel becomes porous, brittle, of a darker fracture, more fusible, and incapable of being forged or welded. On the contrary, steel cemented with earthy infusible powders, is gradually reduced to the state of forged iron again. Simple ignition produces the same effect; but is attended with oxidation of the surface. The texture of steel is rendered more uniform by fusing it before it is made into bars: this is called cast steel; and is rather more difficultly wrought than common steel, because it is more fusible, and is dispersed under the hammer if heated to a white-heat.

The English steel made by cementation, and afterwards fused, and sold under the name of cast steel, in bars, plates, and other forms, possesses great reputation for its uniformity of texture, and other good qualities. I have been informed by various authorities, of which the respectability and connexions are calculated to produce the most absolute confidence, that all the prime steels of England are made from Swedish iron, known in this country by the name of steel iron, of three different marks, the first of which indicates the best quality, and the third the worst.

The conversion of iron into steel, either by fusion, viz. the direct change of crude iron into steel, or by cementation of bar iron, presents many objects of interesting inquiry. From various experiments of Bergmann, it appeared, that good crude iron, kept for a certain time in a state of fusion, with such additions as appeared calculated to produce little other effect than that of defending the metal from oxidation, became converted into steel with loss of weight. These facts are conformable to the general theory of Vandermonde, Monge, and Berthollet: for, according to their researches, it should follow that part of the carbon in the crude iron was dissipated, and the remainder proved to be such in proportion as constitutes steel. The same chemist cemented crude iron with plumbago, or carbonate of iron, and found that the metal had lost no weight. Morveau repeated the experiment with gray crude iron. The loss of weight was little, if any. The metal exhibited the black spot by the application of nitric acid, as steel usually does, but it did not harden by ignition and plunging in water. Hence I conclude, that it was scarcely altered; for crude irons also exhibit the black spot, and cannot by common management acquire the hardness of steel.

By pursuing this train of reflection, it will follow, that, since crude iron differs from steel only in the superabundance of carbon, it ought to be capable of extreme hardness, if ignited to that degree, which is requisite to combine the greater part of this carbon with the iron, and then suddenly cooled. This is accordingly found to be the case. If the gray crude iron, commonly distinguished by our founders by the name of soft metal, be heated to a white heat, and then plunged into water, it becomes very hard, much whiter, denser, and more metallic in its appearance; and will bear a pretty good edge fit for gravers, for the use of turners in iron or steel. In these tools the angle of the planes which form the edge is about 45°. The hardness of this kind of iron is not considerably diminished but by ignition continued for a length of time, which is a fact also conformable to what happens in steel. For the cast steel will be softened nearly as much by annealing to the straw colour, as the harder steels are by annealing to a purple or full blue.

Some of our artists have taken advantage of this property of soft crude iron in the fabrication of axles and collars for wheelwork; for this material is easily filed and turned in its soft state, and may afterward be hardened so as to endure a much longer time of wear.

The founders who cast wheels and other articles of mechanism, are occasionally embarrassed by this property. For, as the metal is poured into their moulds of moistened sand, the evaporation of the water carries off a great portion of the heat, and cools the iron so speedily, as to render it extremely hard, white, and close in its texture. This is most remarkable in such portions of the metal, as have the greatest distance to run from the git or aperture of reception. For these come in contact successively with a larger portion of the sand, and are therefore more suddenly cooled. I have seen the teeth of cog-wheels altogether in this state, while the rim and other parts of the wheel remained soft. The obvious remedy for this defect is to increase the number of gits, and to have the sand as dry as possible or convenient. In other articles this property has been applied to advantage, particularly in the steel rollers for large laminating mills.

I have been informed by a workman, that ignited iron, suddenly plunged into the soft leather of a shoe, becomes very hard on its surface, which must arise from an instantaneous effect of case hardening.

The increase of dimensions acquired by steel in hardening is such, that, in general, pieces of work finished soft will not fit their places when hardened.

The fineness of grain in hard steel, as exhibited in its fracture, is various according to the quality of the metal, and the temper it has received. The harder the steel the coarser the grain. But in like circumstances, fine steel has the closest grain, and is ever the most uniform in its appearance. Workmen avail themselves much of this indication. In general a neat curve lined fracture, and even gray texture, denote good steel; and the appearance of threads, cracks, or brilliant specks, denotes the contrary. But the management of the forging and other circumstances of manufacturing will modify these indications; and the steel that is good for some purposes, may be less suited to others.

It is found, that steel is more effectually hardened in cold than in warm water, and at like temperatures more effectually in mercury than in water. Oil is found to harden the surface of steel much more than its internal part, so that it resists the file, but is much less easily broken by the hammer. Tallow differs from oil in the heat which becomes latent for its fusion; and accordingly, solid tallow is an excellent material for hardening drills and other small articles. The makers of files cover them with the grounds of beer and common salt, which assist their hardening, and keep the surface from scorifying. The mucilage of the beer supplies a coaly matter; and the fused salt forms a varnish in the fire and defends the steel. Very small articles heated in a candle are found to be hardened perfectly by suddenly whirling them in the cold air; and thin bars or plates of steel, such as the magnetic needle of a compass, acquire a good degree of hardness by being ignited, then laid on a plate of cold lead, and suddenly covered with another plate. These would be unequally hardened, and bend, if plunged in water.

The black spot which remains upon steel, or crude iron, after its surface has been corroded by acids, consists of plumbago, which remains after the iron has disappeared by solution.

Solution in the sulphuric or muriatic acid not only exhibits the plumbago contained in iron, but likewise possesses the advantage of showing the state of its reduction by the quantity of hydrogen gas which is disengaged; for the quantity of this gas, in like circumstances, is proportional to that of the iron which is converted into oxide. It is found, that the white crude iron affords the least quantity of hydrogen in proportion to its bulk, and leaves a moderate portion of plumbago; the gray crude iron affords more hydrogen, and more plumbago than the white; and the softest bar iron affords most hydrogen of any, and little or no plumbago. The quantities of hydrogen gas, at a medium, by ounce measures, were 62, afforded by 100 grains of the white crude iron; 71 by the gray crude iron; and 77 by the malleable iron.

Iron is one of the principal ingredients for dyeing black. The stuff is first prepared with a bath of galls and logwood, then with a similar bath to which verdigris is added, and lastly dyed in a similar bath, with the addition of sulphate of iron. If it be wished, that the colour should be particularly fine, the stuff should previously be dyed of a deep blue; otherwise a brown may be first given with the green husks of walnuts. Silk however must not be previously blued with indigo, and sumach may be substituted instead of galls. Leather prepared by tanning with oak bark, is blackened by a solution of sulphate of iron.

Cotton has a very strong affinity for oxide of iron, so that, if it be immersed in a solution of any salt of iron, it assumes a chamois colour, more or less deep according to the strength of the solution. The action of the air on the oxide of iron deepens the colour; and if the shade were at first deep, the texture of the stuff is liable to be corroded by it. To prevent this, the cotton should be immersed in the solution cold, carefully wrung, and immediately plunged into a ley of potash mixed with a solution of alum. After having lain in this four or five hours, it is to be wrung, washed, and dried.

In order to prevent gun-barrels from rusting they are frequently browned. This is done by rubbing it over when finished with aquafortis or spirit of salt diluted with water, and laying it by for a week or two till a complete coat of rust is formed. A little oil is then applied, and the surface, being rubbed dry, is polished by means of a hard brush and a little bees' wax.

The yellow spots called iron moulds, which are frequently occasioned by washing ink spots with soap, may in general be removed by lemon-juice, or the oxalic or citric acids; or by muriatic acid diluted with five or six parts of water, but this must be washed off in a minute or two. Ink spots may readily be removed by the same means. If the iron mould have remained so long, that the iron is very highly oxidized, so as to be insoluble in the acid, a solution of an alkaline sulphuret may be applied, and, after this has been well washed off, the acid will remove the stain.

* To the preceding details, which are selected from Mr. Nicholson's work, I shall subjoin a short systematic view of the chemical nature and relations of iron.

I. *Of pure iron.*

Its specific gravity is 7.7, but it may be made 7.8 by hammering. Under the article Cohesion, the tenacity of iron is given in reference to other solids. In malleability it is much inferior to gold, silver, and copper; though in ductility it approaches these metals; for iron wires of 1-150th of an inch, are frequently drawn. Its melting point is estimated by Sir G. Mackenzie at 158° Wedgewood; the extreme heat of our chemical furnaces.

Dr. Wollaston first showed, that the forms in which native iron is disposed to break, are those of the regular octahedron and tetrahedron, or rhomboid, consisting of these forms combined. In a specimen possessed by this philosopher, the crystalline surfaces appear to have been the result of a process of oxidation which has penetrated the mass to a considerable depth in the direction of its laminæ; but in the specimen which is in the possession of the Geological Society, the brilliant surfaces that have been occasioned by forcible separation from the original mass, exhibit also the same configurations as are usual in the fracture of octohedral crystals, and are found in many simple metals. This spontaneous decomposition of the metal in the direction of its crystalline laminæ is a new and valuable fact.

From Mr. Daniell's ingenious experiments on the mechanical structure of iron, developed by solution, we learn, that a mass of *bar iron* which had undergone all the operations of *puddling* and *rolling*, after being left in liquid muriatic acid, till saturation, presented the appearance of a bundle of fasces, whose fibres run parallel through its whole length. At its two ends, the points were perfectly detached from each other, and the rods were altogether so distinct, as to appear to the eye to be but loosely compacted.

II. *Compounds of iron.*

1. Oxide; of which there are two, or perhaps three.

1. The oxide, obtained either by digesting an excess of iron filings in water, by the combustion of iron wire in oxygen, or by adding pure ammonia to solution of green copperas, and drying the precipitate out of contact of air, is of a black colour, becoming white by its union with water, in the hydrate, attractible by the magnet, but more feebly than iron. By a mean of the experiments of several chemists, its composition seems to be,

Iron,	100	77.82	3.5
Oxygen,	28.5	22.18	1.0

Whence the prime equivalent of iron comes out, we perceive, 3.5. Sir H. Davy's number, reduced to the oxygen scale, is 6.86, one-half of which, 3.43, is very nearly the determination of Berzelius. But Mr. Porrett, in an ingenious paper published in the Annals of Philosophy for October 1819, conceives that to make the theoretical proportions relative to iron harmonize with the experimental results, we must consider 1.75, or the half of 3.5, as its true prime equivalent, or lowest term of combination. The protoxide will then consist of 2 primes of iron to 1 of oxygen.

M. Thenard, in his Traité, vol ii. p. 73. says, the above oxide, obtained by decomposing protosulphate of iron by potash or soda, and washing the precipitate in close vessels with water deprived of its air, consists, according to M. Gay-Lussac, of 100 parts of iron, and 25 of oxygen. This determination would make the atom of iron 4.0; and is probably incorrect. This proportion is proved, he adds, by dissolving a certain quantity of iron in dilute sulphuric acid, and collecting the evolved hydrogen. Now, by this method extreme precision should be ensured.

2. Deutoxide of M. Gay-Lussac. He forms it, by exposing a coil of fine iron wire, placed in an ignited porcelain tube, to a current of steam, as long as any hydrogen comes over. There is no danger, he says, of generating peroxide in this experiment;

because iron, once in the state of deutoxide, has no such affinity for oxygen, as to enable it to decompose water. It may also, he states, be procured by calcining strongly a mixture of 1 part of iron and 3 parts of the red oxide in a stone-ware crucible, to the neck of which a tube is adapted to cut off the contact of air. But this process is less certain than the first; because a portion of peroxide may escape the reaction of the iron. But we may dispense with the trouble of making it, adds M. Thenard, because it is found abundantly in nature. He refers to this oxide, the crystallized specular iron ore of Elba, Corsica, Dalecarlia, and Sweden. He also classes under this oxide, all the magnetic iron ores; and says, that the above described protoxide does not exist in nature. From the synthesis of this oxide by steam, M. Gay-Lussac has determined its composition to be,

Iron, 100 72.72

Oxygen, 37.5 27.28, which Mr. Porrett reconciles to theory, by representing it as consisting of

3 primes iron,		5.25	72.5	100
2	oxygen,	2.00	27.5	38

3. The red oxide. It may be obtained by igniting the nitrate, or carbonate; by calcining iron in open vessels; or simply by treating the metal with strong nitric acid, then washing and drying the residuum. Colcothar of vitriol, or thorough calcined copperas, may be considered as peroxide of iron. It exists abundantly native in the red iron ores. It seems to be a compound of,

		By Mr. Porrett.
Iron,	100	70 = 4 primes.
Oxygen,	43	30 = 3 primes.

2. Chlorides of iron; of which there are two, first examined in detail by Dr. Davy.

The protochloride may by procured by heating to redness, in a glass tube with a very small orifice, the residue, which is obtained by evaporating to dryness the green muriate of iron. It is a fixed substance, requiring a red heat for its fusion. It has a grayish variegated colour, a metallic splendour, and a lamellar texture. It absorbs chlorine when heated in this gas, and becomes entirely converted into the volatile deutochloride. It consists, by Dr. Davy, of

Iron,	46.57
Chlorine,	53.43

By Mr. Porrett,

2 primes iron,		3.5	43.75	100.0
1	chlorine,	4.5	56.25	128.7

The deutochloride may be formed by the combustion of iron wire in chlorine gas, or by gently heating the green muriate in a glass tube. It is the volatile compound, described by Sir H. Davy in his celebrated Bakerian lecture on oxymuriatic acid. It condenses after sublimation, in the form of small brilliant iridescent plates.

It consists, by Dr. Davy, of iron, 35.1
chlorine, 64.9

By Mr. Porrett,

4 primes iron,		7.0	34.14	100.00
3	chlorine,	13.5	65.86	192.85

3. For the *iodide* of iron, See IODINE.

4. Sulphurets of iron; of which, according to Mr. Porrett, there are four, though only two are usually described, his protosulphuret, and persulphuret.

The protosulphuret of iron exists in nature. It has the metallic appearance of bronze; but its powder is blackish-gray. It is in fact the magnetic pyrites of mineralogy, which see among the ORES of iron. By the analyses of Mr. Hatchett and Professor Proust, it seems to consist of iron, 63
sulphur, 37

Mr. Porrett represents it as composed of

2 primes iron		= 3.5	63.75	100
1	sulphur	2.0	36.25	57

His deutosulphate and tritosulphate are as follows:

Deutos.	3 primes iron,		5.25	57	100
	2	sulphur,	4.00	43	76
Tritos.	4 primes iron,		7.0	54	100
	3	sulphur,	6.0	46	86

He conceives, that in Proust's experiments, as related in the 1st volume of Nicholson's 8vo Journal, descriptions of compounds corresponding to those two sulphurets are given.

The protosulphuret is the cubic iron pyrites of the mineralogist. It consists, by Mr. Porrett, of

1 prime iron, 1.75 46.5 100.0

1 sulphur, 2.00 53.5 114.2; and the mean of Mr. Hatchett's celebrated experiments on pyrites, published in the Phil. Trans. for 1804, gives of iron, 100
sulphur, 113

5. Carburets of iron. These compounds form steel, and probably cast iron; though the latter contains also some other ingredients. The latest practical researches on the constitution of these carburets, are those of Mr. Daniell, above quoted.

A mass of steel just taken from the crucible in which it had been fused, was subjected to the action of muriatic acid. It was of a radiated texture. When withdrawn from the solvent, it presented a high crystalline arrangement, composed of minute brilliant plates. A bar of steel of an even granular fracture being broken into two, the pieces were heated in a furnace to a cherry-red. In this state one of them was plunged into cold water, and the other allowed to cool gradually by the slow extinction of the fire. They were then both placed in muriatic acid, to which a few drops of nitric acid had been added. The softened piece of steel was readily attacked; but it required a period five times greater to saturate the acid with the hard piece. When the solvent had ceased to act on both, they were examined. The hard steel was exceedingly brittle, its surface was covered with small cavities like worm-eaten wood, but its texture was very compact, and not at all striated. The other piece was inelastic and flexible, and presented a fibrous and wavy texture. On this texture, the excellence of iron for mechanical purposes is known to depend; and the parts not fibrous are thrown off by the processes of puddling and hammering. By cutting the iron bars into short pieces repeatedly, tying them in bundles, and welding them together, a similar interlacement of fibres is given to this valuable metal, as to flax and hemp, by carding and spinning. May not the superior quality of the Damascus sword blades, which is still a problem, says Mr. Daniell, to our manufacturers, be owing to some such management? A specimen of *white cast iron*, of a radiated fracture, took just three times as long to saturate a given portion of acid, as a cube of *gray cast iron*, or a mass of *bar iron*. Its texture, after this action, appeared to be composed of a congeries of plates, aggregated in various positions, sometimes producing stars upon the surface, from the intersection of their edges. A small bar of *cold short iron*, exceedingly brittle, and presenting in its fracture bright and polished surfaces, resembling antimony, after the action of the acid proved to be fibrous. A rod of *hot short iron* presented, at the end of the operation, a closely compacted mass of very small fibres, perfectly continuous. The congeries was twisted, but the threads preserved their parallelism.

MM. Berzelius and Stromeyer produced a compound, which they consider as a combination of iron, carbon, and silicium, the unknown basis of silica. They mixed into a paste with gum or linseed oil, very pure iron, silex, and charcoal, and heated the mixture very intensely in a covered crucible. They inferred that silicium, in the metallic or inflammable state, existed in the product, because the sum of the iron and silex extracted from the alloy, very sensibly exceeded the total weight of the alloy; because the alloy gave a much greater quantity of hydrogen, with muriatic acid, than the iron alone which it contained would have afforded; and because there is no known combination of a metal with an earth, which requires the successive operation of the most powerful agents to decompose it, as this alloy did. The colour of this compound was that of common steel.

The quantities of the component parts, however, of this alloy, differed very materially, from those of the purified carburet obtained from cast iron. The former varied from the proportions of

Iron,	85.3	to	96.1
Silicium,	9.2		2.2
Carbon,	5.3		1.6

The artificial compound was highly magnetical, while the triple carburet is not. Mr. Daniell, in examining by solution in acid, a cube of gray cast iron, obtained a porous spongy substance, untouched by the menstruum. It was easily cut off by a knife; had a dark gray colour, somewhat resembling plumbago, and when placed in considerable quantity on blotting paper to dry, it spontaneously heated, ignited and scorched the paper. Its properties were not impaired by being left for weeks in the solution of iron, or in water. After a series of elaborate analytical experiments, Mr. Daniell infers the composition of this cast-iron to be,

Iron,	84.66		
Foreign matter,	15.34	silex,	10.43
		double carbur.	4.91
			15.34

And 100 grains of the double carburet of iron and silex upon an average of 5 experiments, gave the following results:

Red oxide of iron,	31.2	= 28.0	black oxide
Silex,	22.3	= 20.6	oxide of silicium?
Carbon,	51.4	= 51.4	
	104.9	100.0	

Although the existence of silicium in the metallic state alloyed with iron, is not actually demonstrated by the preceding experiments, yet it is rendered extremely probable. But, as Mr. Daniell remarks, much remains to be done to complete our knowledge of the nature of cast iron.

The composition of steel is also very variable. According to M. Vauquelin, the carbon forms $\frac{1}{140}$ part, on an average. By enclosing diamonds in cavities of soft iron, and igniting; the former disappeared, and the inner surface of the latter was converted into steel. Mr. Clouet makes the carbon in cast iron = $\frac{1}{4}$ of the whole weight. But Berzelius makes the latter species a very complex compound. A specimen of very pure cast iron analyzed by him, yielded,

Iron,	90.83
Silicium,	0.50
Magnesium,	0.20
Manganese,	4.57
Carbon,	3.90
	100.00

Mr. Mushet has inserted in several volumes of the Phil. Magazine, many excellent papers on the manufacture and habitudes of iron. In the 5th volume of the Manchester Memoirs, a good account of the process used at Sheffield for converting cast iron into pure iron, and pure iron into steel, has been published by Mr. Joseph Collier. He has given a drawing of the steel furnace of cementation. I regret that the limits of this work prevent me from transcribing their valuable communications. I shall merely annex Mr. Muschet's table of the proportions of carbon corresponding to different carburets of iron.

$\frac{1}{120}$ Soft cast steel.

$\frac{1}{100}$ Common cast steel.

$\frac{1}{90}$ The same, but harder.
$\frac{1}{50}$ The same too hard for drawing.
$\frac{1}{25}$ White cast iron.
$\frac{1}{20}$ Mottled cast iron.
$\frac{1}{15}$ Black cast iron.

Graphite or plumbago, is also a carburet of iron; containing about 10 per cent of metal, which calling the prime of iron 1.75, makes it a compound of 21 primes of carbon to 1 of metal. This congregation of carbonaceous atoms, by a singular enough coincidence, is precisely that assigned by Dr. Thomson, in his analysis of coal, as the number clustered round azote, a body whose atomic weight is also 1.75. *See Annals of Phil. for August* 1819, p. 93. This analogy may perhaps be regarded, by those who hunt after harmonic numbers, as at once a demonstration of the atom of iron being 1.75; and of an atom of carbon requiring for saturation 21 atoms of a substance, whose prime equivalent is to its own, as 1.75 is to 0.75. It is, however, rather unlucky for this fancy, that cyanogen or prussine has been discovered.

Pure iron becomes instantly magnetic, when presented to a magnetic bar; and as speedily loses its magnetism, when the bar is withdrawn. Its coercive power, in resisting the decomposition or recomposition of the austral and boreal magnetisms, is extremely feeble. But when iron is combined with oxygen, carbon, sulphur or phosphorus, it acquires the magneto-coercive virtue, which attains a maximum of force, with certain proportions of the constituents, hitherto undetermined. Mr. Hatchett is the only chemist who has adverted to this subject, in a philosophical manner.—"Speaking generally of the carburets, sulphurets, and phosphurets of iron, I have no doubt," says he, "but that, by accurate experiments, we shall find, that a certain proportion of the ingredients of each, constitutes a maximum in the magnetical power of these three bodies."

The most useful alloy of iron, is that with tin, in tin-plate. The surface of the iron plates is cleaned first, by steeping in a crude bran-vinegar, and then in dilute sulphuric acid; after which they are scoured bright with hemp and sand, and deposited in pure water, to prevent oxidation. Into a pot, containing equal parts of grain and block-tin in a state of fusion, covered with tallow, the iron plates are immersed in a vertical direction, having been previously kept for about an hour in melted tallow. From 300 to 400 plates are tinned at a time: each parcel requires an hour and a half for mutual incorporation of the metals. After lifting out the tinned plates, the striæ are removed from their surfaces, and under edges, by subsequent immersion in melted tin, and then in melted tallow, wiping the surfaces at the same time with a hempen brush.

Very curious and instructive experiments on the alloys of steel with several metals, with a view to improve cutting instruments and reflecting mirrors, have been lately made in the laboratory of the Royal Institution, of which an account is inserted in the 18th number of the Journal of Science.

Alloys of steel with platinum, rhodium, gold, and nickel may be obtained, when the heat is sufficiently high. This is so remarkable with platinum, that it will fuse when in contact with steel, at a heat at which the steel itself is not affected.

There are some very curious circumstances, attending the alloy of silver. If steel and silver be kept in fusion together for a length of time, an alloy is obtained, which appears to be very perfect, while the metals are in the fluid state; but on solidifying and cooling, globules of pure silver are expressed from the mass, and appear on the surface of the button. If an alloy of this kind be forged into a bar, and then dissected by the action of dilute sulphuric acid, the silver appears not in combination with the steel, but in threads throughout the mass; so that the whole has the appearance of a bundle of fibres of silver and steel, as if they had been united by welding. The appearance of these silver fibres is very beautiful; they are sometimes one-eighth of an inch in length, and suggest the idea of giving mechanical toughness to steel, where a very perfect edge may not be required. The most interesting result is the following:—When 1 of silver and 500 steel were properly fused together, a very perfect button was produced; no silver appeared on its surface; when forged and dissected by an acid, no fibres were seen, although examined by a high magnifying power. The specimen forged remarkably well, although very hard; it had, in every respect, the most favourable appearance. By a delicate test, every part of the bar gave silver. This alloy is decidedly superior to the very best steel, and this excellence is unquestionably owing to combination with a minute portion of silver. It has been repeatedly made, and always with success. Various cutting tools have been made from it of the best quality. Mr. Stodart, a very eminent cutler, assisted at these experiments, which must give the public confidence in their practical results.

Equal parts by weight, of platinum and steel, form a beautiful alloy, which takes a fine polish, and does not tarnish; the colour is the finest imaginable for a mirror. The sp. gr. of this beautiful compound is 9.862. The proportions of platinum that appear to improve steel for edge instruments, are from 1 to 3 per cent. While an alloy of 10 platinum with 80 steel, after lying many months exposed, had not a speck on its surface; an alloy of 10 nickel with 80 platinum, was in the same circumstances covered with rust.

The alloys of steel with rhodium, would prove highly valuable, were it not for the scarcity of the latter metal.

There is a species of steel made in India, called *wootz*, possessed of excellent qualities, which seems to have been successfully imitated in these late experiments at the Royal Institution. In a previous number of the same Journal, (14th), Mr. Faraday had detailed a minute, and apparently, a very accurate analysis, operated on a part of one of the cakes of wootz, presented by the Right Hon. Sir Joseph Banks, to Mr. Stodart. 460 grains gave 0.3 of a grain of silex, 0.6 of a grain of alumina. 420 grains of the best English steel, furnished by Mr. Stodart, afforded no earths whatever. The imitative synthesis was performed in the following way:—

Pure steel in small pieces, and, in some instances, good iron being mixed with charcoal powder, were intensely heated for a long time. Thus, carburets, having a dark green metallic colour, were formed, highly crystallized, resembling somewhat the black ore of tellurium. When broken, the facets of small buttons, not weighing more than 500 grains, were frequently above the eighth of an inch in width. The results of several experiments on its composition, which appeared very uniform, gave 94.36 iron + 5.64 carbon. This being broken and rubbed to powder in a mortar, was mixed with pure alumina, and the whole intensely heated in a close crucible for a considerable time. On being removed from the furnace and opened, an alloy was obtained of a white colour, a close granular texture, and very brittle. This, when analyzed, gave 6.4 per cent. of alumina, and a portion of carbon not accurately estimated. 700 of good steel, with 40 of the alumina alloy, were fused together, and formed a very good button perfectly malleable. This, on being forged into a little bar, and the surface polished, gave, on the application of sulphuric acid, the beautiful damask, peculiar to wootz. A second experiment was made with 500 grains of the same steel, and 67 of the alumina alloy, which also proved good. It forged well, and gave the damask. This specimen had all the appreciable characters of the best Bombay wootz. It is highly probable, that the much admired sabres of Damascus, are made from this steel; and if this be admitted, there can be little reason to doubt, that the damask itself is merely an exhibition of crystallization. Wootz requires for tempering, to be heated fully 40° F. above the best English cast steel; and affords a finer and more durable edge.

When soft steel is ignited to a cherry-red, and suddenly plunged in cold water, it is rendered so hard as to resist the file, and nearly as brittle as glass. The tempering of steel consists in reducing this excessive hardness to a moderate degree, by a gentle heating, which also restores its toughness and elasticity. In the year 1789, Mr. Hartley obtained a patent for a mode of tempering cutting instruments of steel, by immersion in oil, heated to a regulated temperature, measured by a thermometer. This was certainly a great improvement, both in point of precision and despatch, on the common method of heating the instrument over a flame, till a certain colour, produced by a film of oxide, appears on its surface. These colours are,

At 430° F.	a very faint yellow, for lancets.
450	a pale straw-colour for razors and surgeons' instruments.
470	a full yellow, for penknives.
490	a brown colour, for scissars and chisels for cutting cold iron.
510	a brown, with purple spots, for axes and plane-irons.
530	a purple, for table-knives and large shears.
550	a bright blue, for swords, watch-springs, truss-springs, and bell-springs.
560	a full blue, for small fine saws, daggers, &c.
600	dark blue, verging on black, is the softest of all the gradations; when the metal becomes fit only for hand and pit-saws, which must be soft, that their teeth may bear sharpening by the file, and setting by the hammer, or pliers.

If the steel be heated still further, it becomes perfectly soft. When tools having a thick back and thin edge, like penknives, are to be tempered, they are placed with their back on a plate of hot iron or on hot sand; otherwise they would become too soft at the edge, before the backs would be sufficiently heated. To prevent warping of long blades, or bars for magnets, they are generally hardened by being plunged vertically into water. It is evident, that melted pewter, covered with grease, may be used instead of hot oil for tempering steel; the heat being regulated by a thermometer.

Salts of iron.

These salts have the following general characters:—

1. Most of them are soluble in water; those with the protoxide for a base, are generally crystallizable; those with the peroxide, are generally not; the former are insoluble, the latter soluble in alcohol.

2. Ferroprussiate of potash throws down a blue precipitate, or one becoming blue in the air.

3. Infusion of galls gives a dark purple precipitate, or one becoming so in the air.

4. Hydrosulphuret of potash or ammonia gives a black precipitate; but sulphuretted hydrogen merely deprives the solutions of iron of their yellow-brown colour.

5. Phosphate of soda gives a whitish precipitate.

6. Benzoate of ammonia, yellow.

7. Succinate of ammonia, flesh-coloured with the peroxide.

1. *Protacetate of iron* forms small prismatic crystals, of a green colour, a sweetish styptic taste, and a sp. gr. 1.368.

2. *Peracetate of iron* forms a reddish-brown uncrystallizable solution, much used by the calico printers, and prepared by keeping iron-turnings, or pieces of old iron, for six months immersed in redistilled pyrolignous acid. See Acid (Acetic.)

3. *Protarseniate of iron* exists native in crystals, and may be formed in a pulverulent state, by pouring arseniate of ammonia into sulphate of iron. It is insoluble, and consists, according to Chenevix, of 38 acid, 43 oxide, and 19 water, in 100 parts.

4. *Perarseniate of iron* may be formed by pouring arseniate of ammonia into peracetate of iron; or by boiling nitric acid on the protarseniate. It is insoluble.

5. *Antimoniate of iron* is white, becoming yellow, insoluble.
6. *Borate*, pale yellow, insoluble.
7. *Benzoate*, yellow, do.
8. *Protocarbonate*, greenish, soluble.
9. *Percarbonate*, brown, insoluble.
10. *Chromate*, blackish, do.
11. *Protocitrate*, brown crystals, soluble.
12. *Protoferroprussiate*, white, insoluble.
13. *Perferroprussiate*, blue, do.

This constitutes the beautiful pigment called prussian blue. When exposed to a heat of about 400°, it takes fire in the open air; but in close vessels it is decomposed, apparently into carburetted hydrogen, water, and hydrocyanate of ammonia, which come over; while a mixture of charcoal and oxide of iron remains in the state of a pulverulent pyrophorus, ready to become inflamed with contact of air. I have already considered the constitution of prussian blue, in treating of the Acid (Ferroprussic); and have little farther to add to what is there stated concerning this intricate compound. I perceive that Dr. Thomson has recently published (Ann. of Phil. for September 1820) a new igneous analysis of prussian blue. He gives now satisfactory evidence, that hydrocyanate of ammonia is one of the products, which his former short notice left somewhat in doubt. But the details of his analysis are blended with so many theoretical suppositions, that instead of clearing up the matter, they seem to involve it in greater mystery.

I shall avail myself, however, of this opportunity of presenting my readers with the valuable investigations of M. Robiquet on the nature of prussian blue, published in the 12th vol. of the *Ann. de Chimie et Physique*.

When sulphuric acid is added to prussian blue, it makes it perfectly white, apparently by abstracting its water; for the blue colour returns on dilution of the acid, and if the strong acid be poured off, it yields no traces of either prussic acid or iron. On submitting pure prussian blue for some time to the action of sulphuretted hydrogen water, small brilliant crystals of a yellowish colour appeared, which became blue in the air, and were protoprussiate of iron: M. Robiquet has succeeded in obtaining the acid of prussian blue in a *solid crystalline state*, by a different process from Mr. Porrett's. Strong muriatic acid, in large quantity, being mixed with pure prussian blue, and left for some time, the sediment becomes of a green colour, and then yellow. If water be added to this mixture, it is again rendered blue; but if no water be added, and if it be allowed to stand in a narrow vessel, the sediment falls to the bottom, and a deep red-brown solution covers it. This is an acid solution of muriate of iron, and cannot be made to produce a blue by any method tried. The sediment was allowed to contract itself for several days, and the supernatant liquor being drawn off by a little syphon, the washing was then repeated with concentrated muriatic acid as before, until the process was supposed to be complete. The magma was now collected into a capsule, and placed in a receiver, containing much lime, to dry. When dry it was digested in alcohol, filtered and evaporated spontaneously, and a number of small crystals were obtained. These crystals were separated, washed in fresh alcohol, and again crystallized; and were then the pure acid of prussian blue, or the ferrochyazic acid of Mr. Porrett.

These crystals appear at times to be tetrahedral; they are white when pure; but become slightly blue by exposure to the air. They have no odour; their taste is acid and peculiar, without being like that of prussic acid. They are soluble in water and alcohol. The colourless solution produces an immense precipitate of prussian blue, in persulphate of iron. The acid perfectly saturates potash, and produces the common triple prussiate of potash. If it be heated, a considerable quantity of prussic acid first passes off, the remainder becomes of a deep blue colour, and insoluble.—When heated in close vessels, the prussic acid is given off as before, perfectly pure, and no other effect takes place, if the temperature be below that of boiling mercury. The residue is yellowish-brown, but becomes nearly black in the air; it contains ammonia, and the iron is in such a state of combination, that it is not affected either by sulphuric acid or the magnet. If this residuum be heated still higher, then prussic acid in small quantities, and hydrogen and azote, in the proportion of one to two, come off, and charcoal and metallic iron remain. No carbonic acid is found in this experiment; hence the iron is in the metallic state in the acid. M. Robiquet concludes from this experiment, that the peculiar acid is a combination of prussic acid and cyanuret (prusside) of iron, formed by affinities so powerful, that the poisonous properties of the prussic acid are entirely neutralized and lost.

"It results," says M. Robiquet, "from what has been said,—

"1. That potash is an essential element in the white prussiate of iron.

"2. That the protoprussiate of iron is slightly soluble in water, capable of being crystallized, and of a yellow colour.

"3. That the acid of prussian blue, and of triple prussiates in general, is a combination of iron, cyanogen, and prussic acid.

"4. That prussian blue, and the triple prussiates in general, are formed of a cyanuret and a hydrocyanate (a prusside and prussiate).

"5. That it is probable that prussian blue owes its colour to a certain quantity of water."

These curious details of M. Robiquet have the air of chemical research, and do him much honour.

I consider Mr. Porrett's process for obtaining crystallized ferroprussic acid to be more elegant than M. Robiquet's. He dissolved 58 gr. of crystallized tartaric acid in spirit of wine, and poured the solution into a phial containing 50 gr. of ferruretted chyazate of potash dissolved in 2 or 3 drachms of warm water: by this process the whole of the tartaric acid will combine with, and precipitate the potash, in the state of supertartrate of potash, and the alcoholic fluid will contain nothing but ferruretted chyazic acid, which may be obtained from it, in small crystals, generally resembling a cube, by spontaneous evaporation.—*Annals of Philosophy for September* 1818.

14. *Protogallate*, colourless, soluble.

15. *Pergallate*, purple, insoluble.

16. *Protomuriate*, green crystals, very soluble.

17. *Permuriate*, brown, uncrystallizable, very soluble. See the *chlorides of iron* previously described.

18. *Protonitrate*, pale green, soluble.

19. *Pernitrate*, brown, do.

20. *Protoxalate*, green prisms, do.

21. *Peroxalate*, yellow, scarcely soluble.

22. *Protophosphate*, blue, insoluble.

23. *Perphosphate*, white, insoluble.

24. *Protosuccinate*, brown crystals, soluble.

25. *Persuccinate*, brownish-red, insoluble.

26. *Protosulphate*, green vitriol, or copperas. It is generally formed by exposing native pyrites to air and moisture, when the sulphur and iron both absorb oxygen, and form the salt. There is, however, an excess of sulphuric acid, which must be saturated by digesting the lixivium of the decomposed pyrites with a quantity of iron plates or turnings.

It forms beautiful green crystals, which are transparent rhomboidal prisms, whose faces are rhombs with angles of 79° 50′ and 100° 10′ inclined to each other at angles of 98° 37′ and 81° 23′. Sp. gr. 1.84. Its taste is harsh and styptic. It reddens vegetable blues. Two parts of cold and three-fourths of boiling water dissolve it. It does not dissolve in alcohol. Exposure to air converts the surface of the crystals into a red deutosulphate. A moderate heat whitens it, by separating the water of crystallization, and a stronger heat drives off the sulphuric acid. Its constituents are 28.9 acid, 28.3 protoxide, and 45 water, according to Berzelius; consisting, by Mr. Porrett's views, of 1 prime acid + 2 oxide + 7 water.

27. *Persulphate.* Of this salt there seems to be four or more varieties, having a ferreous base, which consists, by Mr. Porrett, of 4 primes iron + 3 oxygen = 10 in weight, from which their constitution may be learned.

The tartrate and pertartrate of iron may also be formed; or, by digesting cream of tartar with water on iron filings, a triple salt may be obtained, formerly called tartarized tincture of Mars.

Iron is one of the most valuable articles of the materia medica. The protoxide acts as a genial stimulant and tonic, in all cases of chronic debility not connected with organic congestion or inflammation. It is peculiarly efficacious in chlorosis. It appears to me that the peroxide and its combinations are almost uniformly irritating, causing heartburn, febrile heat, and quickness of pulse. Many chalybeate mineral waters contain an exceedingly minute quantity of protocarbonate of iron, and yet exercise an astonishing power in recruiting the exhausted frame. I believe their virtue to be derived simply from the metal being oxidized to a minimum, and diffused by the agency of a mild acid through a great body of water, in which state it is rapidly taken up by the lacteals, and speedily imparts a ruddy hue to the wan countenance. I find that these qualities may be imitated exactly, by dissolving 3 grains of sulphate of iron, and 60 of bicarbonate of potash, in a quart of cool water, with agitation in a close vessel.*

* **Iron-flint.** Eeisenkiesel.—*Werner.* Colours, brown and red. Massive, and crystallized in small equiangular six-sided prisms, acuminated on both extremities. It occurs commonly in small angulo-granular distinct concretions. Lustre, vitreo-resinous. Fracture small conchoidal. Opaque. Gives sparks with steel. Rather difficultly frangible. Sp. gr. 2.6 to 2.8. Infusible. Its constituents are 93.5 silica, 5 oxide of iron, and 1 volatile matter. The red iron-flint contains 21.7 oxide of iron, and 76.8 silica. It occurs in veins in ironstone, and in trap-rocks, near Bristol, in the island of Rathlin, at Dunbar, and in many parts of Germany.—*Jameson.**

* **Isatis Tinctoria.** The plant used for dyeing, called *woad.**

* **Iserine.** Colour, iron-black. In small obtuse angular grains. Lustre splendent or glistening, and metallic. Fracture conchoidal. Opaque. Harder than feldspar. Brittle. Retains its colour in the streak. Sp. gr. 4.6. It melts into a blackish-brown glass, which is slightly attracted by the magnet. The mineral acids have no effect on it, but oxalic acid extracts a portion of the titanium. Its constituents are 48 oxide of titanium, 48 oxide of iron, and 4 uranium, by Dr. Thomson's analysis of the iserine, found in the bed of the river Don, in Aberdeenshire; but, by Klaproth, it consists of 28 oxide of titanium, and 72 oxide of iron. On the continent it has hitherto been found only in the lofty Riesengebirge, near the origin of the stream called the Iser, disseminated in granite sand; and in alluvial soil along with pyrope in Bohemia. —*Jameson.**

Isinglass. This substance is almost wholly gelatin; 100 grains of good dry isinglass containing rather more than 98 of matter soluble in water.

Isinglass is made from certain fish found in the Danube, and the rivers of Muscovy. Willoughby and others inform us, that it is made of the sound of the Beluga; and Neumann, that it is made of the Huso Germanorum, and other fish, which he has frequently seen sold in the public markets of Vienna. Mr. Jackson remarks, that the sounds of cod, properly prepared, afford this substance; and that the lakes of America abound with fish from which the very finest sort may be obtained.

Isinglass receives its different shapes in the following manner:—

The parts of which it is composed, particularly the sounds, are taken from the fish while sweet and fresh, slit open, washed from their slimy *sordes*, divested of a very thin membrane which envelops the sound, and then exposed to stiffen a little in the air. In this state they are formed into rolls about the thickness of a finger, and in length according to the intended size of the staple: a thin membrane is generally selected for the centre of the roll, round which the rest are folded alternately, and about half an inch of each extremity of the roll is turned inwards.

Isinglass is best made in the summer, as frost gives it a disagreeable colour, deprives it of weight, and impairs its gelatinous principles.

Isinglass boiled in milk forms a mild nutritious jelly, and is thus sometimes employed medicinally. This, when flavoured by the art of the cook, is the blanc-manger of our tables. A solution of isinglass in water, with a very small proportion of some balsam, spread on black silk, is the court-plaster of the shops.

Ivory. The tusk, or tooth of defence of the male elephant. It is an intermediate substance between bone and horn, not capable of being softened by fire, not altogether so hard and brittle as bone. Sometimes it grows to an enormous size, so as to weigh nearly two hundred pounds.

The entire tooth is of a yellowish, brownish, and sometimes a dark-brown colour on the outside; internally white, hollow towards the root, and so far as was inserted into the jaw, of a blackish-brown colour. The finest, whitest, smoothest, and most compact ivory comes from the island of Ceylon. The grand consumption of this commodity is for making ornamental utensils, mathematical instruments, cases, boxes, balls, combs, dice, and an infinity of toys. The workmen have methods also of tinging it of a variety of colours.

Merat Guillot obtained from 100 parts of ivory, 24 gelatin, 64 phosphate of lime, and 0.1 carbonate of lime.

The coal of ivory is used in the arts under the denomination of ivory-black. Particular vessels are used in the manufactory of the pigment, for the purpose of rendering it perfectly black.

Some travellers speak of the tooth of the sea-horse as an excellent ivory; but it is too hard to be sawed or wrought like ivory. It is used for making artificial teeth.

K

KALI. See POTASH.

KAOLIN. The chinese name of porcelain clay.

KEDRIA TERRESTRIS. Barbadoes tar. See BITUMEN.

* **KELP.** Incinerated sea-weed. See SODA.*

KERMES (*coccus ilicis*, Lin.) is an insect found in many parts of Asia, and the south of Europe.

On account of their figure, they were a long time taken for the seeds of the tree on which they live; whence they were called *grains of kermes*. They also bore the name of vermilion.

To dye spun worsted with kermes, it is first boiled half an hour in water with bran, then two hours in a fresh bath with one-fifth of Roman alum, and one-tenth of tartar, to which *sour water* is commonly added; after which it is taken out, tied up in a linen bag, and carried to a cool place, where it is left some days. To obtain a full colour, as much kermes as equals three-fourths, or even the whole of the weight of the wool, is put into a warm bath, and the wool is put in at the first boiling. As cloth is more dense than wool, either spun or in the fleece, it requires one-fourth less of the salts in the boiling, and of kermes in the bath.

The colour that kermes imparts to wool has much less bloom than the scarlet made with cochineal; whence the latter has generally been preferred, since the art of heightening its colour by means of solution of tin has been known.

KERMES MINERAL. See ANTIMONY.

* **KIFFEKILL.** See MEERSCHAUM.*

* **KINATE OF LIME.** A salt which forms 7 per cent of cinchona. See ACID (KINIC).*

KINO. A few years ago this was introduced into our shops and medical practice by the name of a *gum;* but Dr. Duncan has shown that it is an extract. * It contains also a species of *tannin*, whence it is used as an astringent in diarrhœas.*

* **KLEBSCHIEFER.** Adhesive slate.*

* **KONITE.** See CONITE.*

* **KOUMISS.** A vinous liquid, which the *Tartars* make by fermenting mare's milk. Something similar is prepared in Orkney and Shetland.*

KUPFER NICKEL. See NICKEL.

L

LABDANUM. A resin of a species of cistus in Candia, of a blackish colour. The country people collect it by means of a staff, at the end of which are fastened many leather thongs, which they gently strike on the trees. They form it into cylindrical pieces, which are called *labdanum in tortis*. It is greatly adulterated by the addition of black sand. It has been used in cephalic and stomachic plasters and perfumes.

LABORATORY. A place properly fitted up for the performance of chemical operations.

As chemistry is a science founded entirely on experiment, we cannot hope to understand it well, without making such experiments as verify most of the known fundamental operations, and also such as reasoning, analogy, and the spirit of inquiry, never fail to suggest to those, whose taste and suitable talents lead them to this essential part of experimental philosophy. Besides, when a person himself observes, and operates, he must perceive, even in the most common operations, a great variety of small facts, which must necessarily be known, but which are not mentioned either in books or in memoirs, because they are too numerous, and would appear too minute. Lastly, there are many qualities in the several agents, of which no just notion can be given by writing, and which are perfectly well known as soon as they have been once made to strike our senses.

Many people think, that a laboratory level with the ground is most convenient, for the sake of water, pounding, washing, &c. It certainly has these advantages; but it is also subject to very great inconvenience from moisture.

Constant moisture, though not very considerable and sensible in many respects, is a very great inconvenience in a chemical laboratory. In such a place, most saline matters become moist in time, and the inscriptions fall off, or are effaced; the bellows rot; the metals rust; the furnaces moulder, and every thing almost spoils. A laboratory, therefore, is more advantageously placed above than below the ground, that it may be as dry as possible. The air must have free access to it; and it must even be so constructed, that, by means of two or more opposite openings, a current of air may be admitted, to carry off any noxious vapours or dust.

In the laboratory a chimney ought to be constructed, so high that a person may easily stand under it, and as extensive as is possible; that is, from one wall to another. The funnel of this chimney ought to be as high as is possible, and sufficiently contracted to make a good draught. As charcoal only is burnt under this chimney, no soot is collected in it; and therefore it need not be so wide as to allow a chimney-sweeper to pass up into it.

Under this chimney may be constructed some brick furnaces, particularly a melting furnace, a furnace for distilling with an alembic, and one or two ovens like those in kitchens. The rest of the space ought to be filled up with stands of different heights, from a foot to a foot and a half, on which portable furnaces of all kinds are to be placed. These furnaces are the most convenient, from the facility of disposing them at pleasure; and they are the only furnaces which are necessary in a small laboratory. A double pair of bellows of moderate size must also be placed as commodiously under the chimney, or as near as the place will allow. These bellows are sometimes mounted in a portable frame; which is sufficiently convenient when the bellows are not more than 18 or 20 inches long. These bellows ought to have a pipe directed toward the hearth where the forge is to be placed.

The necessary furnaces are, the simple furnace, for distilling with a copper alembic; a lamp furnace; two reverberatory furnaces of different sizes, for distilling with retorts; an air or melting furnace, an essay furnace, and a forge furnace.

Under the chimney, at a convenient height, must be a row of hooks driven into the back and side walls; upon which are to be hung small shovels; iron pans; tongs; straight, crooked, and circular pincers; pokers; iron rods, and other utensils for disposing the fuel and managing the crucibles.

To the walls of the laboratory ought to be fastened shelves of different breadths and heights; or these shelves may be suspended by hooks. The shelves are to contain glass vessels, and the products of operations, and ought to be in as great a number as is possible. In a laboratory where many experiments are made, there cannot be too many shelves.

The most convenient place for a stone or leaden cistern, to contain water, is a corner of the laboratory, and under it a sink ought to be placed with a pipe, by which the water poured into it may discharge itself. As the vessels are always cleaned under this cistern, cloths and bottle brushes ought to be hung upon hooks fastened in the walls near it.

In the middle of the laboratory a large table is to be placed, on which mixtures are to be made, preparations for operations, solutions, precipitations, small filtrations; in a word, whatever does not require fire, excepting that of a lamp.

In convenient parts of the laboratory are to be placed blocks of wood upon mats; one of which is to support a middle-sized iron mortar; another to support a middle-sized marble, or rather hard stone mortar; a third to support an anvil. Near the mortars are to be hung searces of different sizes and fineness; and near the anvil, a hammer, files, rasps, small pincers, scissars, sheers, and other small utensils, necessary to give metals a form proper for the several operations.

Two moveable trestles ought to be in a laboratory, which may serve to support a large filter mounted upon a frame, when it is required. This apparatus is removed occasionally to the most convenient place.

Charcoal is an important article in a laboratory, and it therefore must be placed within reach; but as the black dust which flies about it, whenever it is stirred, is apt to soil every thing in the laboratory, it had better be in some place near the laboratory; together with some furze, which is very convenient for kindling fires quickly. This place serves, at the same time, for containing bulky things, which are not often wanted; such as furnaces, bricks, tiles, clay, fire-clay, quicklime, sand, and many other things necessary for chemical operations.

Lastly, a middle-sized table, with solid feet, ought to be enumerated among the large moveables of a laboratory, the use of which is to support a porphyry, or levigating stone, or rather a very hard and dense grit-stone, together with a muller made of the same kind of stone.

The other small moveables or utensils of a laboratory are, small hand mortars of iron, glass, agate, and Wedgwood's ware, and their pestles; earthen, stone, metal, and glass vessels, of different kinds, funnels, and measures.

Some white writing paper, and some unsized paper for filters; a large number of clean straws, eight or ten inches long, for stirring mixtures in glasses, and for supporting paper filters placed in glass funnels.

Glass tubes for stirring and mixing corrosive liquors; spatulas of wood, ivory, metal, and glass.

Thin pasteboards, and horns, very convenient for collecting matters bruised with water upon the levigating stone, or in mortars; corks of all sizes; bladders and linen strips for luting vessels.

A good portable pair of bellows; a good steel for striking fire; a glue-pot, with its little brush; lastly, a great many boxes, of various sizes, for containing most of the above-mentioned things, and which are to be placed upon the shelves.

Beside these things, some substances

are so necessary in most chemical operations, that they may be considered as instruments requisite for the practice of this science. These substances are called reagents, which see under ORES (ANALYSIS OF), and WATERS (MINERAL).

All metals, which ought to be very pure.

A person provided with such instruments and substances, may at once perform many chemical experiments.

The general observations of Macquer upon the conducting of chemical processes, are truly valuable and judicious. Method, order, and cleanliness, are essentially necessary in a chemical laboratory. Every vessel and utensil ought to be well cleansed as often as it is used, and put again into its place: labels ought to be put upon all the substances. These cares, which seem to be trifling, are however very fatiguing and tedious; but they are also very important, though frequently little observed. When a person is keenly engaged, experiments succeed each other quickly, some seem nearly to decide the matter, and others suggest new ideas; he cannot but proceed to them immediately, and he is led from one to another: he thinks he shall easily know again the products of the first experiments, and therefore he does not take time to put them in order: he prosecutes with eagerness the experiments which he has last thought of; and in the mean time, the vessels employed, the glasses and bottles filled, so accumulate, that he cannot any longer distinguish them; or at least, he is uncertain concerning many of his former products. This evil is increased, if a new series of operations succeed, and occupy all the laboratory; or if he be obliged to quit it for some time, every thing then goes into confusion. Thence it frequently happens, that he loses the fruits of much labour, and that he must throw away almost all the products of his experiments.

When new researches and inquiries are made, the mixtures, results, and products of all the operations ought to be kept a long time, distinctly labelled and registered; for these things, when kept some time, frequently present phenomena, that were not at all suspected. Many fine discoveries in chemistry have been made in this manner; and many have certainly been lost by throwing away too hastily, or neglecting the products.

Since chemistry offers many views for the improvement of many important arts; as it presents prospects of many useful and profitable discoveries; those who apply their labours in this way ought to be exceedingly circumspect, not to be led into a useless expense of money and time. In a certain set of experiments, some one is generally of an imposing appearance, although in reality it is nothing more. Chemistry is full of these half successes, which serve only to deceive the unwary, to multiply the number of trials, and to lead to great expense before the fruitlessness of the search is discovered. By these reflections we do not intend to divert from all such researches, those whose taste and talents render them fit for them; on the contrary, we acknowledge, that the improvement of the arts, and the discovery of new objects of manufacture and commerce, are undoubtedly the finest and most interesting part of chemistry, and which make that science truly valuable; for without these ends, what would chemistry be but a science purely theoretical, and capable of employing only some abstract and speculative minds, but useless to society? We acknowledge also, that the successes in this kind of chemical inquiry are not rare; and that their authors have sometimes acquired fortunes, so much the more honourable, as being the fruits of their talents and industry. But we repeat, that, in these researches, the more dazzling and near any success appears, the more circumspection, and even distrust is necessary. See ANALYSIS, ATTRACTION, BALANCE.

The plates annexed, with the following explanations of them, will give the student an idea of a large variety of the most useful and necessary articles of a chemical apparatus.

Plate II. fig. 1. Crucibles or pots, made either of earth, black lead, forged iron, or platina. They are used for roasting, calcination, and fusion.

Fig. 2. Cucurbits, matrasses, or bodies, which are glass, earthen, or metallic vessels, usually of the shape of an egg, and open at top. They serve the purposes of digestion, evaporation, &c.

Fig. 3. Retorts are globular vessels of earthen ware, glass, or metal, with a neck bended on one side. Some retorts have another neck or opening at their upper part, through which they may be charged, and the opening may be afterwards closed with a stopple. These are called tubulated retorts. A Welter's tube of safety may be inserted in this opening, instead of a stopple. See Plate VII. fig. 1. *b* and *e*.

Receivers are vessels, usually of glass, of a spherical form, with a straight neck, into which the neck of the retort is usually inserted. When any proper substance is put into a retort, and heated, its volatile parts pass over into the receiver, where they are condensed. See fig. 5. and Plate V. fig. 2. *k*.

Fig. 4. The alembic is used for distillation, when the products are too volatile to admit of the use of the last mentioned apparatus. The alembic consists of a body *a*, to which is adapted a head *b*. The head is of a conical figure, and has its external

circumference or base depressed lower than its neck, so that the vapours which rise, and are condensed against its sides, run down into the circular channel formed by its depressed part, from whence they are conveyed by the nose or beak *c*, into the receiver *d*. This instrument is less simple than the retort, which certainly may be used for the most volatile products, if care be taken to apply a gentle heat on such occasions. But the alembic has its conveniences. In particular the residues of distillations may be easily cleared out of the body *a*; and in experiments of sublimation, the head is very convenient to receive the dry products, while the more volatile and elastic parts pass over into the receiver.

Fig. 6. Represents the large stills used in the distillation of ardent spirits. *a* represents the body, and *b* the head, as before. Instead of using a refrigeratory or receiver, the spirit is made to pass through a spiral pipe called the worm, which is immersed in a tub of cold water *d*. During its passage it is condensed, and comes out at the lower extremity, *e*, of the pipe, in a fluid form.

The manner in which the excise laws for Scotland were formed, rendering it advantageous to the distillers in that country to have stills of small capacity, which they could work very quickly, their ingenuity was excited to contrive the means of effecting this. It was obvious, that a shallow still, with a broad bottom completely exposed to a strong heat, would best answer the purpose; and this was brought to such perfection, that a still of the capacity of 40 gallons in the body, and three in the head, charged with 16 gallons of wash, could be worked 480 times in 24 hours. Fig. 7. is a vertical section of this still, *a* the bottom, joined to *b*, the shoulder, with solder, or rivets, or screws and lute. *c*, the turned-up edge of the bottom, against which, and on a level with *a*, the brickwork of the coping of the flue rests, preventing the flame from getting up to touch *c*. *d*, the discharge pipe. *e e*, the body of the still. *f*, section of the central steam escape pipe. *g*, section of one of the lateral steam escape pipes; *h*, outside view of another. *i i i i*, inferior apertures of lateral steam pipes; *k k k k*, their superior apertures. *l l*, bottom scraper, or agitator, which, may either be made to apply close to the bottom, or to drag chains; *m*, the upright shaft of this engine, as it is called; *n* the horizontal wheel with its supporters. *o*, its vertical wheel. *p*, its handle and shaft; *n*, support of the shaft. *r*, froth and ebullition jet-breaker, resting on the cross bar *s*. *t*, its upright shaft. *u*, its cup-mouthed collar, filled with wool and grease, and held down by a plate and screws. *v*, general steam escape pipe, or head. The charge pipe, and the sight hole, for the man who charges it to see when it is sufficiently full, are not seen in this view.

The best construction of a furnace has not been well ascertained from experience. There are facts which show, that a fire made on a grate near the bottom of a chimney, of equal width throughout, and open both above and below, will produce a more intense heat than any other furnace. What may be the limits for the height of the chimney is not ascertained from any precise trials; but thirty times its diameter would not probably be too high. It seems to be an advantage to contract the diameter of a chimney, so as to make it smaller than that of the fire-place, when no other air is to go up the chimney than what has passed through the fire; and there is no prospect of advantage to be derived from widening it.

Plate V. fig. 3. exhibits the wind or air-furnace for melting. *a* is the ash-hole, *f* an opening for the air. *c* is the fire-place, containing a covered crucible, standing on a support of baked earth, which rests on the grate. *d* is the passage into *e*, the chimney. At *d* a shallow crucible or cupel may be placed in the current of the flame, and at *x* is an earthen or stone cover, to be occasionally taken off for the purpose of supplying the fire with fuel.

Fig. 2. is a reverberatory furnace. *a a* the ash-pit and fire-place. *b b* body of the furnace. *c c* dome, or reverberating roof of the furnace. *d d* chimney. *e e* door of the ash-pit. *f f* door of the fire-place. *g g* handles of the body. *h* aperture to admit the head of the retort. *i i* handles of the dome. *k* receiver. *l l* stand of the receiver. *m m* retort, represented in the body by dotted lines.

Another reverberatory furnace, a little differing in figure, may be seen in Plate 1. fig. 2.

M. Chenevix has constructed a wind furnace, which is in some respects to be preferred to the usual form. The sides, instead of being perpendicular, are inverted, so that the hollow space is pyramidical. At the bottom the opening is 13 inches square, and at the top but eight. The perpendicular height is 17 inches. This form appears to unite the following advantages: 1st, A great surface is exposed to the air, which having an easy entrance, rushes through the fuel with great rapidity; 2d, The inclined sides act in some measure as reverberating surfaces; and 3d, The fuel falls of itself, and is always in close contact with the crucible placed near the grate. The late Dr. Kennedy of Edinburgh, whose opinion on this subject claims the greatest weight, found that the strongest heat in our common wind furnaces was within two or three inches of the grate. This, therefore, is the most advantageous position for the crucible, and still more so when we can keep it surrounded with fuel. It is inconvenient, and dangerous for the crucible, to stir the fire often to make the fuel fall, and the pyramidical form renders this unnecessary. It is also more easy to avoid a sudden bend in the chimney, by the upper part of the furnace advancing as in this construction. In plate V. fig. 1. *a* is a grate; *c* and *c* are two bricks, which can be let in at pleasure to diminish the capacity; *b* is another grate, which can be placed upon the bricks *c* and *c* for smaller purposes; *d* and *d* are bricks which can be placed upon the grate *b* to diminish the upper capacity, so that, in fact, there are four different sizes in the same furnace. The bricks should all be ground down to the slope of the furnace, and fit in with tolerable accuracy. They are totally independent of the pyramidical form of the furnace.

Mr. Aikin's portable blast furnace is composed of three parts, all made out of the common thin black lead melting pots, sold in London for the use of the goldsmiths. The lower piece *c*, fig. 6. is the bottom of one of these pots, cut off so low as only to leave a cavity of about an inch deep, and ground smooth above and below. The outside diameter, over the top, is five inches and a half. The middle-piece or fire-place *a*, is a larger portion of a similar pot, with a cavity about six inches deep, and measuring seven inches and a half over the top, outside diameter, and perforated with six blast holes at the bottom. These two pots are all that are essentially necessary to the furnace for most operations; but when it is wished to heap up fuel above the top of a crucible contained, and especially to protect the eyes from the intolerable glare of the fire when in full height, an upper pot *b* is added, of the same dimensions as the middle one, and with a large opening in the side, cut to allow the exit of the smoke and flame. It has also an iron stem, with a wooden handle (an old chisel answers the purpose very well) for removing it occasionally. The bellows, which are double (*d*), are firmly fixed, by a little contrivance which will take off and on, to a heavy stool, as represented in the plate; and their handle should be lengthened so as to make them work easier to the hand. To increase their force, on particular occasions, a plate of lead may be firmly tied on the wood of the upper flap. The nozzle is received into a hole in the pot *c*, which conducts the blast into its cavity. Hence the air passes into the fire-place *a*, through six holes of the size of a large gimlet, drilled at equal distances through the bottom of the pot, and all converging in an inward direction, so that, if prolonged, they would meet about the centre of the upper part of the fire. No luting is necessary in using this furnace, so that it may be set up and taken down immediately. Coak, or common cinders, taken from the fire when the coal ceases to blaze, sifted from the dust, and broken into very small pieces, forms the best fuel for higher heats. The fire may be kindled at first by a few lighted cinders, and a small quantity of wood charcoal. The heat which this little furnace will afford is so intense, that its power was at first discovered accidentally by the fusion of a thick piece of cast iron. The utmost heat procured by it was 167 degrees of Wedgwood's pyrometer, when a Hessian crucible was actually sinking down in a state of porcelaneous fusion. A steady heat of 155° or 160° may be depended on, if the fire be properly managed, and the bellows worked with vigour.

The process of cupellation may be exhibited in a lecture, or performed at other times, by means of this furnace. The method consists in causing a portion of the blast to be diverted from the fuel, and to pass through a crucible in which the cupel is placed. This arrangement supplies air; and the whole may be seen by a sloping tube, run through the cover of the crucible.

Charcoal is the material most commonly used in furnaces. It produces an intense heat without smoke, but it is consumed very fast. Coak or charred pit-coal produces a very strong and lasting heat. Neither of these produces a strong heat at a distance from the fire. Where the action of flame is required, wood or coal must be burned. Several inconveniences attend the use of coal, as its fuliginous fumes, and its aptitude to stop the passage of air by becoming fused. It is used, however, in the reverberatory furnaces of glass-houses, and is the best material where vessels are to be supplied with a great quantity of heat at no great intensity, such as in distilleries, &c.

Frequently, however, the flame of an Argand lamp may be employed very conveniently for chemical purposes. Pl. VI. fig. 2. is a representation of a lamp furnace, as it is perhaps not very properly called, as improved by Mr. Accum. It consists of a brass rod screwed to a foot of the same metal, loaded with lead. On this rod, which may be unscrewed in the middle for rendering it more portable, slide three brass sockets with straight arms, terminating in brass rings of different diameters. The largest measures four inches and a half. These rings serve for supporting glass alembics, retorts, Florence flasks, evaporating basins, gas bottles, &c.; for performing distillations, digestions, solutions, evaporations, saline fusions, concentrations, analyses with the pneumatic apparatus, &c. If the vessels require not to be exposed to the naked fire, a copper sand-bath may be interposed, which is to be previously placed in the ring. By means of a thumb-screw acting on the rod of the lamp, each of the brass rings may be set at different heights, or turned aside, according to the pleasure of the operator. Below these rings is a fountain-lamp on Argand's plan, having a metallic valve within, to prevent the oil from running out while the reservoir is put into its place. This lamp also slides on the main brass rod by means of a socket and thumb-screw. It is therefore easy to bring it nearer, or to move it further, at pleasure, from the vessel, which may remain fixed; a circumstance which, independent of the elevation and depression of the wicks of the lamp, affords the advantage of heating the vessels by degrees after they are duly placed, as well as of augmenting or diminishing the heat instantly; or for maintaining it for several hours at a certain degree, without in the least disturbing the apparatus suspended over it. It may therefore be used for producing the very gentle heat necessary for the rectification of ethers, or the strong heat requisite for distilling mercury. The chief improvement of this lamp consists in its power of affording an intense heat by the addition of a second cylinder, added to that of the common lamp of Argand. This additional cylinder encloses a wick of one inch and a half in diameter, and it is by this ingenious contrivance, which was first suggested by Mr. Webster, that a double flame is caused, and more than three time the heat of an Argand's lamp of the largest size is produced.

Every effect of the most violent heat of furnaces may be produced by the flame of a candle or lamp, urged upon a small particle of any substance, by the blow-pipe. This instrument is sold by the ironmongers, and consists merely of a brass pipe about one-eighth of an inch diameter at one end, and the other tapering to a much less size, with a very small perforation for the wind to escape. The smaller end is bended on one side. For philosophical or other nice purposes the blow-pipe is provided with a bowl or enlargement *a* (Pl. V. fig. 5.), in which the vapours of the breath are condensed and detained, and also with three or four small nozzles, *b*, with different apertures, to be slipped on the smaller extremity. These are of use when larger or smaller flames are to be occasionally used, because a larger flame requires a large aperture, in order that the air may effectually urge it upon the matter under examination.

There is an artifice in the blowing through this pipe, which is more difficult to describe than to acquire. The effect intended to be produced is a continual stream of air for many minutes, if necessary, without ceasing. This is done by applying the tongue to the roof of the mouth, so as to interrupt the communication between the mouth and the passage of the nostrils; by which means the operator is at liberty to breathe through the nostrils, at the same time that by the muscles of the lips he forces a continual stream of air from the anterior part of the mouth through the blow-pipe. When the mouth begins to be empty, it is replenished by the lungs in an instant, while the tongue is withdrawn from the roof of the mouth, and replaced again in the same manner as in pronouncing the monosyllable *tut*. In this way the stream may be continued for a long time without any fatigue, if the flame be not urged too impetuously, and even in this case no other fatigue is felt than that of the muscles of the lips.

A wax candle, of a moderate size, but thicker wick than they are usually made with, is the most convenient for occasional experiments; but a tallow candle will do very well. The candle should be snuffed rather short, and the wick turned on one side toward the object, so that a part of it should lie horizontally. The stream of air must be blown along this horizontal part, as near as may be without striking the wick. If the flame be ragged and irregular, it is a proof, that the hole is not round or smooth; and if the flame have a cavity through it, the aperture of the pipe is too large. When the hole is of a proper figure and duly proportioned, the flame consists of a neat luminous blue cone, surrounded by another flame of a more faint and indistinct appearance. The strongest heat is at the point of the inner flame.

The body intended to be acted on by the blow-pipe ought not to exceed the size of a peppercorn. It may be laid upon a piece of close-grained, well-burned charcoal; unless it be of such a nature as to sink into the pores of this substance, or to have its properties affected by its inflammable quality. Such bodies may be placed in a small spoon made of pure gold or silver, or platina.

Many advantages may be derived from the use of this simple and valuable instrument. Its smallness, which renders it suitable to the pocket, is no inconsiderable recommendation. The most expensive materials, and the minutest specimens of bodies, may be used in these experiments; and the whole process, instead of being carried on in an opaque vessel, is under the eye of the observer from beginning to end. It is true, that very little can be determined in this way concerning the quantities of products; but, in most cases, a knowledge of the contents of any substance is a great acquisition, which is thus obtained in a very short time, and will at all events serve to show the best and least expensive way of conducting processes with the same matters in the larger way.

The blow-pipe has deservedly of late years been considered as an essential instrument in a chemical laboratory, and several attempts have been made to facilitate its use by the addition of bellows, or some other equivalent instruments. These are doubtless very convenient, though they render it less portable for mineralogical researches. It will not, here, be necessary to enter into any description of a pair of double bellows fixed under a table, and communicating with a blow-pipe which passes through the table. Smaller bellows, of a portable size for the pocket, have been made for the same purpose. The ingenious chemist will find no great difficulty in adapting a bladder to the blow-pipe, which, under the pressure of a board, may produce a constant stream of air, and may be replenished, as it becomes empty, by blowing into it with bellows, or the mouth, at another aperture furnished with a valve opening inwards.

The chief advantage these contrivances have over the common blow-pipe is, that they may be filled with oxygen gas, which increases the activity of combustion to an astonishing degree. The vapour from alcohol has likewise been employed, and an ingenious contrivance for this purpose by Mr. Hooke is represented, Pl. V. fig. 4. *a* is a hollow sphere for containing alcohol, resting upon a shoulder in the ring *o*. If the bottom be made flat instead of spherical, the action of the flame will then be greater. *b* is a bent tube with a jet at the end, to convey the alcohol in the state of vapour into the flame at *q*; this tube is continued in the inside up to *c*, which admits of *a* being filled nearly, without any alcohol running over. *d* is a safety valve, the pressure of which is determined at pleasure, by screwing higher or lower on the pillar *e*, the two milled nuts *f* and *g* carrying the steel arm *h*, which rests on the valve. *i* is an opening for putting in the alcohol. *k* is the lamp, which adjusts to different distances from *a*, by sliding up or down the two pillars *l l*. The distance of the flame *q* from the jet is regulated by the pipe which holds the wick being a little removed from the centre of the brass piece *m*, and of course revolving in a circle. *n* the mahogany stand.

For the various habitudes of bodies when examined by the blow-pipe, see Blow-pipe.

Little need be said concerning the manner of making experiments with fluid bodies in the common temperature of the atmosphere. Basins, cups, phials, matrasses, and other similar vessels, form the whole apparatus required for the purpose of containing the matters intended to be put together; and no other precaution or instruction is required, than to use a vessel of such materials as shall not be corroded or acted upon by its contents, and of sufficient capacity to admit of any sudden expansion or frothing of the fluid, if expected. This vessel must be placed in a current of air, if noxious fumes arise, in order that these may be blown from the operator.

The method of making experiments with permanently elastic fluids, or gases, though simple, is not so obvious. We live immersed in an atmosphere not greatly differing in density from these fluids, which for this reason are not sufficiently ponderous to be detained in open vessels by their weight. Their remarkable levity, however, affords a method of confining them by means of other denser fluids. Dr. Priestley, whose labours so far exceeded those of his predecessors and contemporaries, both in extent and importance, that he may with justice be styled the father of this important branch of natural philosophy, used the following apparatus.

Pl. VI. fig. 1. *a* represents a wooden vessel or tub; *k*, *k*, *k*, is a shelf fixed in the tub. When this apparatus is used, the tub is to be filled with water to such a height, as to rise about one inch above the upper surface of the shelf. *b*, *g*, *f*, are glass jars inverted with their mouths downward, which rest upon the shelf. If these, or any other vessels open only at one end, be plunged under the water, and inverted after they are filled, they will remain full, notwithstanding their being raised out of the water, provided their mouths be kept immersed; for in this case, the water is sustained by the pressure of the atmosphere, in the same manner as the mercury in the barometer. It may without difficulty be imagined, that if common air, or any other fluid resembling common air in lightness and elasticity, be suffered to enter these vessels, it will rise to the upper part, and the surface of the water will subside. If a bottle, a cup, or any other vessel, in that state which is usually called empty, though really full of air, be plunged into the water with its mouth downwards, scarce any water will enter, because its entrance is opposed by the elasticity of the included air; but if the vessel be turned up, it immediately fills, and the air rises in one or more bubbles to the surface. Suppose this operation to be performed under one of the jars which are filled with water, the air will ascend as before; but instead of escaping, it will be detained in the upper part of the jar. In this manner, therefore, we see, that air may be emptied out of one vessel into another by an inverted pouring, in which the air is made to ascend from the lower vessel *i* to the upper *g*, in which the experiments are performed, by the action of the weightier fluid, exactly similar to the common pouring of denser fluids, detained in the bottoms of open vessels, by the simple action of gravity. When the receiving vessel has a narrow neck, the air may be poured through a glass funnel *h*.

c (*Ibid.*) is a glass body or bottle, the bottom of which is blown very thin, that it may support the heat of a candle suddenly applied, without cracking. In its neck is fitted, by grinding, a tube *d*, curved neatly in the form of the letter *s*. This kind of vessel is very useful in various chemical operations, for which it will be convenient to have them of several sizes. In the figure, the body *c* is represented as containing a fluid, in the act of combining with a substance that gives out air, which passes through the tube into the jar *b*, under the mouth of which the other extremity of the tube is placed. At *e* is a small retort of glass or earthenware, the neck of which being plunged in the water, beneath the jar *f*, is supposed to emit the elastic fluid, extricated from the contents of the retort, which is received in the jar.

When any thing, as a gallipot, is to be supported at a considerable height within a jar, it is convenient to have such wire stands as are represented fig. 3. These answer better than any other, because they take up but little room, and are easily bent to any figure or height.

In order to expel air from solid substances by means of heat, a gun-barrel, with the touch-hole screwed up and rivetted, may be used instead of an iron retort. The subject may be placed in the chamber of the barrel, and the rest of the bore may be filled with dry sand, that has been well burned, to expel whatever air it might have contained. The stem of a tobacco-pipe, or a small glass tube, being luted in the orifice of the barrel, the other extremity must be put into the fire, that the heat may expel the air from its contents. This air will of course pass through the tube, and may be received under an inverted vessel, in the usual manner.

But the most accurate method of procuring air from several substances by means of heat, is to put them, if they will bear it, into phials full of quicksilver, with the mouths inverted in the same, and then throw the focus of a burning lens or mirror upon them. For this purpose, their bottoms should be round and very thin, that they may not be liable to fly with the sudden application of heat. The body *c*, Pl. VI. fig. 1. answers this purpose very well.

Many kinds of air combine with water, and therefore require to be treated in an apparatus, in which quicksilver is made use of. This fluid being very ponderous, and of considerable price, it is an object of convenience, as well as economy, that the trough and vessels should be smaller than when water is used. See Pl. VII. fig. 1. *ff*.

When trial is to be made of any kind of air, whether it be fit for maintaining combustion, the air may be put into a long narrow glass vessel, the mouth of which, being carefully covered, may be turned upward. A bit of wax candle being then fastened to the end of a wire, which is bent so that the flame of the candle may be uppermost, is to be let down into the vessel, which must be kept covered till the instant of plunging the lighted candle into the air.

Where the change of dimensions, which follows from the mixture of several kinds of air, is to be ascertained, a graduated narrow cylindrical vessel may be made use of. The graduations may be made by pouring in successive equal measures of water into this vessel, and marking its surface at each addition. The measure may be afterward used for the different kinds of air, and the change of dimensions will be shown by the rise or fall of the mercury or water in the graduated vessel. The purity of common air being determinable by the diminution produced by the addition of nitric oxide gas, these tubes have been called eudiometer tubes.

Some substances, more especially powders, cannot conveniently be put into a phial, or passed through a fluid. When air is to be extricated from, or added to these, there is no better method, than to place them on a stand under the receiver of the air-pump, and exhaust the common air, instead of excluding it by water or mercury. This process requires a good air-pump, and careful management, otherwise the common air will not be well excluded.

It is frequently an interesting object, to pass the electric spark through different kinds of air, either alone or mixed together. In this case a metallic wire may be fastened in the upper end of a tube, and the sparks or shock may be passed through this wire to the mercury or water used to confine the air. If there be reason to apprehend, that an expansion in the air may remove the mercury or water beyond the striking distance, another wire may be thrust up to receive the electricity, or two wires may be cemented into opposite holes in the sides of an hermetically sealed tube. Holes may be made in glass, for this and other chemical uses, by a drill of copper or soft iron, with emery and water; and where this instrument is wanting, a small round file with water will cut a notch in small vessels, such as phials or tubes, though with some danger of breaking them. In some electrical experiments of the kind here mentioned, there is reason to expect a fallacious result from the wires being burned by the explosion or spark. For this reason, the electricity may be made to pass through the legs of a syphon, containing the air which is under consideration in the upper part of its curvature. One of the vessels, in which the legs of the syphon rest, must therefore be insulated; and if any watery fluid be used to confine the air, it is generally supposed that no combustion takes place.

It is sometimes desirable to impregnate water for medicinal purposes with some gas, as the carbonic acid, and for this the apparatus of Dr. Nooth is very effectual and convenient. It consists of three glass vessels, Pl. VI. fig. 4. The lower vessel *c* contains the effervescent materials; it has a small orifice at *d*, stopped with a ground stopper, at which an additional supply of either acid or water, or chalk, may be occasionally introduced. The middle vessel *b* is open, both above and below. Its inferior neck is fitted by grinding into the neck *h* of the lower vessel. In the former is a glass valve, formed by two pieces of tube, and a plano-convex lens, which is moveable, between them, as represented in fig. 5. This valve opens upwards, and suffers the air to pass; but the water cannot return through the tubes, partly because the orifice is capillary, and partly because the flat side of the lens covers the hole. The middle vessel is furnished with a cock *e*, to draw off its contents. The upper vessel *a* is fitted, by grinding, into the upper neck of the middle vessel. Its inferior part consists of a tube that passes almost as low as the centre of the middle vessel. Its upper orifice is closed by a ground stopper *f*. When this apparatus is to be used, the effervescent materials are put into the lower vessel, the middle vessel is filled with pure water, and put into its place; and the upper vessel is stopped, and likewise put in its place. The consequence is, that the carbonic acid gas, passing through the valve at *h*, ascends into the upper part of the middle vessel *b*, where, by its elasticity, it reacts on the water, and forces part up the tube into the vessel *a*; part of the common air, in this last, being compressed, and the rest escaping by the stopper, which is made of a conical figure, that it may be easily raised. As more carbonic acid is extricated, more water rises, till at length the water in the middle vessel falls below the lower orifice of the tube. The gas then passes through the tube into the upper vessel, and expels more of the common air by raising the stopper. In this situation the water in both vessels being in contact with a body of carbonic acid gas, it becomes strongly impregnated with this gas, after a certain time. This effect may be hastened by taking off the middle and upper vessels together, and agitating them.

The valve is the most defective part of this apparatus; for the capillary tube does not admit the air through, unless there is a considerable quantity condensed in the lower vessel; and the condensation has in some instances burst the vessel.

Modern discoveries respecting bodies in the aëriform state have produced several capital improvements in the vessels used for distillation. It was common with the earliest chemists, to make a small hole in the upper part of their retorts, that the elastic vapours might escape, which would otherwise have burst the vessels. By this means they lost a very considerable part of their products. Sometimes too it is requisite, to obtain separately the condensable fluid that comes over, and the gases that are and are not soluble in water. For this purpose a series of receivers, more or less in number as the case may require, is generally employed, as in Pl. VII. fig. 1, which represents what is called Woulfe's apparatus, though in fact its original inventor was Glauber, with some subsequent improvements. The vapour that issues from the retort being condensed in the receiver *a*, the gas passes on through a bent tube into the bottle *c*, which is half filled with water. The gas, not absorbed by this water, passes through a similar bent tube to *d*, and so on to more, if it be thought necessary; while the gas that is not absorbable by water, or condensable, at its exit from the last bottle is conveyed by a recurved tube into a jar *g*, standing in a mercurial trough *ff*.

It often happens in chemical processes, from the irregularity of the heat, or other circumstances, that the condensation is more rapid in proportion to the supply of vapour at some period of the same operation than in others; which would endanger the fluid's being forced backward, by the pressure of the atmosphere, into the receiver, or even into the retort, To prevent this, Mr. Woulfe's bottles had a central neck, beside the two here delineated, for the insertion of a tube of safety, the lower extremity of which opened underneath the water, and the upper communicated with the atmosphere, so as to supply air in case of sudden absorption. See Pl, VII. fig. 3, *h*. Instead of this, however, a curved Welter's tube is now generally used, as more convenient. Into this tube water is poured, till the ball *b*, or *e*, fig. 1. is half full: when absorption takes place, the water rises in the ball till none remains in the tube, and then the air rushes in: on the other hand, no gas can escape, as it has to overcome the pressure of a high column of water in the perpendicular tube.

Another contrivance to prevent retrograde pressure is that of Mr. Pepys. This consists in placing over the first receiver a glass vessel, the neck of which is ground into it, and furnished with a glass valve, similar to that in Nooth's apparatus, so that whenever sudden condensation takes place in the receiver, its effect is merely to occasion a vacuum there.

An ingenious modification of Woulfe's apparatus is that of Mr, Knight, Pl. VI. fig. 6. *a a a* represent three vessels each ground into the mouth of that below it. *b b b* glass tubes, the middles of which are ground into the neck of their respective vessels, the upper extremity standing above the surface of the liquor in the vessel, and the lower extremity reaching nearly to the bottom of the vessel beneath. *e* a Welter's tube to prevent absorption. *f* an adapter ground to fit the receiver; to which any retort may be joined and luted before it is put into its place. *c* a tube for conveying the gas into a pneumatic trough. The foot of the lowest vessel, *d*, slides in between two grooves in a square wooden foot, to secure the apparatus from oversetting. A stopple fitted to the upper vessel, instead of the adapter *f*, converts it into a Nooth's apparatus; the materials being put into the vessel *a*, and in this case it has the advantage of not having a valve liable to be out of order.

A very simple and commodious form of a Woulfe's apparatus is given by the late Dr. W. Hamilton, at the end of his translation of Berthollet on Dyeing; see Pl. VII. fig. 3. *a* is the retort, the neck of which is ground into and passed through the thick collar *b*, represented separately at *b*, with its ground stopple *a*, which may be put in when the neck of the retort is withdrawn. The collar *b* is ground into the wide neck of the receiver *c*, the narrow neck of which is ground into the wide neck of *d*. *d*, *e*, *f*, and *g*, are connected in a similar manner; and into the small necks of *d*, *e*, and *f*, are ground the tubes *i*, *k*, and *l*, so curved, that their lower extremities nearly reach the bottom of the receiver into which they open. From the last receiver proceeds the recurved tube *m*, opening under an inverted cup *n*, a hole in the bottom of which conveys the gas issuing from it into one of the bottle placed in the moveable frame *p*, which has a heavy leaden foot to keep it steady in the centre of a flat pan of water, in which the mouths of the bottles are immersed. In the receiver *d* is a tube of safety *h*. The receivers are placed on a stand a little inclined, and kept steady by slips of wood hollowed out to fit their curvatures, as represented at *s s*. This apparatus requires no lute; has no bent tubes that are difficult to adjust, and liable to break; and the retort may be removed at any stage of the process, either to find the weight it has lost, or for any other purpose, the receiver being meanwhile closed with the stopple. Similar advantages attend Mr. Knight's.

When it is required to pass an aëriform fluid through a red-hot substance, such an apparatus as that of Barruel, Pl. I. fig. 2. may be employed. In this, three gun-barrels, *b*, *c*, *d*, are placed horizontally in a reverberatory furnace *a*, about two inches distance from each other. From the extremity of the central barrel *c*, a bent tube *k* conveys the gas to the jar *m*, in the pneumatic trough *l*. The other extremity of *c* is connected with *d* by the curved tube *i*; *d* with *b* by the curved tube *h*; and the other end of *b* with the bottle *f* by the tube *e*. When this apparatus is employed for obtaining carbonic oxide, the part of each barrel exposed to the fire being filled with charcoal pressed lightly in, but not rammed hard; carbonate of lime diluted with a very little water being poured into the bottle *f*; and the junctures being all well luted, the fire is to be kindled. As soon as the barrels are red-hot, sulphuric acid is to be poured into the funnel *g*, and the carbonic acid gas expelled, traversing three portions of red-hot charcoal, will completely saturate itself with it before it reaches the receiver *m*.

Plate VII. fig. 2. represents the different parts of the apparatus required for measuring the quantity of elastic fluid given out during the action of an acid on calcareous soils. The bottle for containing the soil is represented at *a*; *b* the bottle containing the acid, furnished with a stop-cock; *c* the tube connected with a flaccid bladder *d*; *f* a graduated measure; *e* the bottles for containing the bladder. When this instrument is used, a given quantity of soil is introduced into *a*; *b* is filled with muriatic acid, diluted with an equal quantity of water; and the stop-cock, being closed, is connected with the upper orifice of *a*, which is ground to receive it. The tube *c* is introduced into the lower orifice of *a*, and the bladder connected with it placed in its flaccid state in *e*, which is filled with water. The graduated measure is placed under the tube of *e*. When the stop-cock of *b* is turned, the acid flows into *a*, and acts upon the soil; the elastic fluid generated passes through *c* into the bladder, and displaces a quantity of water in *e* equal to it in bulk, and this water flows through the tube into the graduated measure; the water in which gives, by its volume, the indication of the proportion of carbonic acid disengaged from the soil; for every ounce measure of which, two grains of carbonate of lime may be estimated. See CARBONATE, EUDIOMETER, and VAPOUR.

LABRADORE STONE. See FELDSPAR.

LAC, is a substance well known in Europe, under the different appellations of stick-lac, shell-lac, and seed-lac. The first is the lac in its natural state, encrusting small branches or twigs. Seed-lac is the stick-lac separated from the twigs, appearing in a granulated form, and probably deprived of part of its colouring matter by boiling. Shell-lac is the substance which has undergone a simple purification, as mentioned below. Beside these we sometimes meet with a fourth, called lump-lac, which is the seed-lac melted and formed into cakes.

Lac is the product of the coccus lacca, which deposites its eggs on the branches of a tree called Bihar, in Assam, a country bordering on Thibet, and elsewhere in India. It appears designed to answer the purpose of defending the eggs from injury, and affording food for the maggot in a more advanced state. It is formed into cells, finished with as much art and regularity as a honeycomb, but differently arranged; and the inhabitants collect it twice a-year, in the months of February and August. For the purification, it is broken into small pieces, and put into a canvass bag of about four feet long, and not above six inches in circumference. Two of these bags are in constant use, and each of them held by two men. The bag is placed over a fire, and frequently turned, till the lac is liquid enough to pass through its pores; when it is taken off the fire, and twisted in different directions by the men who hold it, at the same time dragging it along the convex part of a plantain tree prepared for this purpose; and while this is doing, the other bag is heating, to be treated in the same way. The mucilaginous and smooth surface of the plantain tree prevents its adhering; and the degree of pressure regulates the thickness of the coating of lac, at the same time that the fineness of the bag determines its clearness and transparency.

Analyzed by Mr. Hatchett, stick-lac gave in 100 parts, resin 68, colouring extract 10, wax 6, gluten 5.5, extraneous substances 6.5; seed-lac, resin, 88.5, colouring extract 2.5, wax 4.5, gluten 2; shell-lac, resin 90.9, colouring extract 0.5, wax 4, gluten 2.8. The gluten greatly resembles that of wheat, if it be not precisely the same; and the wax is analogous to that of the myrica cerifera.

In India, lac is fashioned into rings, beads, and other trinkets; sealing-wax, varnishes, and lakes for painters, are made from it; it is much used as a red dye, and wool tinged with it, is employed as a fucus by the ladies; and the resinous part, melted and mixed with about thrice its weight of finely powdered sand, forms polishing stones. The lapidaries mix powder of corundum with it in a similar manner.

The colouring matter is soluble in water; but 1 part of borax to 5 of lac, renders the whole soluble by digestion in water, nearly at a boiling heat. This solution is equal for many purposes to spirit varnish, and is an excellent vehicle for water colours, as when once dried, water has no effect on it. Lixivium of potash, soda and carbonate of soda, likewise dissolve it. So does nitric acid, if digested upon it in sufficient quantity 48 hours.

The colouring matter of the lac loses considerably of its beauty by keeping any length of time; but when extracted fresh, and precipitated as a lake. it is less liable to injury. Mr. Stephens, a surgeon in Bengal, sent home a great deal prepared in this way, which afforded a good scarlet to cloth previously yellowed with quercitron; but it would probably have been better, if, instead of precipitating with alum, he had employed a solution of tin, or merely evaporated the decoction to dryness.

Lac is the basis of the best sealing-wax.

* **Lactates.** Definite compounds of lactic acid with the salifiable bases.*

Lacquer. Solution of lac in alcohol.

Lake. This term is used to denote a species of colours formed by precipitating colouring matter with some earth or oxide. The principal lakes are, Carmine, Florence-lake, and lake from Madder.

For the preparation of *Carmine*, four ounces of finely pulverized cochineal are to be poured into four or six quarts of rain or distilled water, that has been previously boiled in a pewter kettle, and boiled with it for the space of six minutes longer; (some advice to add, during the boiling, two drachms of pulverized crystals of tartar). Eight scruples of Roman alum in powder are then to be added, and the whole kept upon the fire one minute longer. As soon as the gross powder has subsided to the bottom, and the decoction is become clear, the latter is to be carefully decanted into large cylindrical glasses covered over, and kept undisturbed, till a fine powder is observed to have settled at the bottom. The superincumbent liquor is then to be poured off from this powder, and the powder gradually dried. From the decanted liquor, which is still much coloured, the rest of the colouring matter may be separated by means of the solution of tin, when it yields a carmine little inferior to the other.

For the preparation of *Florentine* lake, the sediment of cochineal, that remained in the kettle, may be boiled with the requisite quantity of water, and the red liquor likewise, that remained after the preparation of the carmine mixed with it, and the whole precipitated with the solution of tin. The red precipitate must be frequently edulcorated with water. Exclusively of this, two ounces of fresh cochineal, and one of crystals of tartar, are to be boiled with a sufficient quantity of water, poured off clear, and precipitated with the solution of tin, and the precipitate washed. At the same time, two pounds of alum are also to be dissolved in water, precipitated with a lixivium of potash, and the white earth repeatedly washed with boiling water. Finally, both precipitates are to be mixed together in their liquid state, put upon a filter, and dried. For the preparation of a *cheaper* sort, instead of cochineal, one pound of Brazil wood may be employed in the preceding manner.

For the following process for making a *lake from madder*, the Society of Arts voted Sir H. C. Englefield their gold medal. Enclose two ounces troy of the finest Dutch crop madder in a bag of fine and strong calico, large enough to hold three or four times as much. Put it into a large marble or porcelain mortar, and pour on it a pint of clear soft water cold. Press the bag in every direction, and pound and rub it about with a pestle, as much as can be done without tearing it, and when the water is loaded with colour, pour it off. Repeat this process till the water comes off but slightly tinged, for which about five pints will be sufficient. Heat all the liquor in an earthen or silver vessel, till it is near boiling, and then pour it into a large basin, into which a troy ounce of alum dissolved in a pint of boiling soft water has been previously put. Stir the mixture together, and while stirring, pour in gently about an ounce and a half of a saturated solution of subcarbonate of potash. Let it stand till cold to settle; pour off the clear yellow liquor; add to the precipitate a quart of boiling soft water, stirring it well; and when cold, separate by filtration the lake, which should weigh half an ounce. If less alum be employed, the colour will be somewhat deeper; with less than three-fourths of an ounce, the whole of the colouring matter will not unite with the alumina. Fresh madder root is equal, if not superior, to the dry.

Almost all vegetable colouring matters may be precipitated into lakes, more or less beautiful, by means of alum or oxide of tin.

Lamp. See **Light.**

* **Lamp of Safety**, for coal mines, the invaluble and splendid invention of Sir H. Davy. For an account of the principles on which it acts, see **Combustion.** We shall here describe its construction.

In the parts of coal-mines where danger was apprehended from fire-damp, miners had been accustomed to guide themselves, or to work, by the light afforded by the sparks of steel, struck off from a wheel of flint. But even this apparatus, though much less dangerous than a candle, sometimes produced explosions of the fire-damp.

A perfect security from accident is, however, offered to the miner in the use of a safe-lamp, which transmits its light, and is fed with air, through a cylinder of iron or copper wire-gauze; and this fine invention has the advantage of requiring no machinery, no philosophical knowledge to direct its use, and is made at a very cheap rate.

The apertures in the gauze should not be more than $\frac{1}{22}$ of an inch square. As the fire-damp is not inflamed by ignited wire, the thickness of the wire is not of importance, but wire from $\frac{1}{40}$ to $\frac{1}{60}$ of an inch in diameter is the most convenient.

The cage or cylinder should be made by double joinings, the gauze being folded over in such a manner, as to leave no apertures. When it is cylindrical, it should not be more than two inches in diameter; for in larger cylinders, the combustion of the fire-damp renders the top inconveniently hot; and a double top is always a proper precaution, fixed $\frac{1}{2}$ or $\frac{3}{4}$ of an inch above the first top.

The gauze cylinder should be fastened to the lamp, by a screw of four or five turns, and fitted to the screw by a tight ring. All joinings in the lamp should be made with hard solder; and the security depends upon the circumstance, that no aperture exists in the apparatus, larger than in the wire gauze.

The parts of the lamp are,

1. The brass cistern which contains the oil, pierced near the centre with a vertical narrow tube, nearly filled with a wire which is recurved above, on the level of the burner, to trim the wick, by acting on the lower end of the wire, with the fingers. It is called the safety-trimmer.

2. The rim, in which the wire-gauze cover is fixed, and which is fastened to the cistern by a moveable screw.

3. An aperture for supplying oil, fitted with a screw or a cork, and which communicates with the bottom of the cistern by a tube; and a central aperture for the wick.

4. The wire-gauze cylinder, which should not have less that 625 apertures to the square inch.

5. The second top $\frac{3}{4}$ of an inch above the first, surmounted by a brass or copper plate, to which the ring of suspension is fixed.

6. Four or six thick vertical wires, joining the cistern below, with the top plate, and serving as protecting pillars round the cage.

When the wire-gauze safe-lamp is lighted and introduced into an atmosphere gradually mixed with fire-damp, the first effect of the fire-damp, is to increase the length and size of the flame. When the inflammable gas forms as much as $\frac{1}{12}$ of the volume of the air, the cylinder becomes filled with a feeble blue flame, but the flame of the wick appears burning brightly within the blue flame, and the light of the wick augments till the fire-damp increases to $\frac{1}{6}$ or $\frac{1}{5}$, when it is lost in the flame of the fire-damp, which in this case fills the cylinder with a pretty strong light. As long as any *explosive* mixture of gas exists in contact with the lamp, so long it will give light, and when it is extinguished, which happens when the foul air constitutes as much as $\frac{1}{3}$ of the volume of the atmosphere, the air is no longer proper for respiration; for though animal life will continue where flame is extinguished, yet it is always with suffering. By fixing a coil of platinum wire above the wick, ignition will continue in the metal when the lamp itself is extinguished, and from the ignited wire, the wick may be again rekindled, on going into a less inflammable atmosphere.

"We have frequently used the lamps where the explosive mixture was so high, as to heat the wire-gauze red-hot; but on examining a lamp which has been in constant use for three months, and occasionally subjected to this degree of heat, I cannot perceive that the gauze cylinder of iron wire is at all impaired. I have not, however, thought it prudent, in our present state of experience, to persist in using the lamps under such circumstances, because I have observed, that in such situations the particles of coal dust floating in the air, fire at the gas burning within the cylinder, and fly off in small luminous sparks. This appearance, I must confess, alarmed me in the first instance, but experience soon proved that it was not dangerous.

"Besides the facilities afforded by this invention, to the working of coal-mines, abounding in fire-damp, it has enabled the directors and superintendents to ascertain, with the utmost precision and expedition, both the presence, the quantity, and correct situation of the gas. Instead of creeping inch by inch with a candle, as is usual, along the galleries of a mine suspected to contain fire-damp, in order to ascertain its presence, we walk firmly on with the safe-lamps, and, with the utmost confidence, prove the actual state of the mine. By observing attentively the several appearances upon the flame of the lamp, in an examination of this kind, the cause of accidents which happened to the most experienced and cautious miners, is completely developed; and this has hitherto been in a great measure matter of mere conjecture.

"It is not necessary that I should enlarge upon the national advantages which must necessarily result from an invention, calculated to prolong our supply of mineral coal, because I think them obvious to every reflecting mind; but I cannot conclude, without expressing my highest sentiments of admiration for those talents, which have developed the properties, and controlled the power, of one of the most dangerous elements, which human enterprize has hitherto had to encounter."—See Letter to Sir H. Davy, in Journal of Science, vol. i. p. 302. by John Buddle, Esq. generally and justly esteemed the most scientific coal-miner in the kingdom.*

***Lana Philosophica.** The snowy flakes of white oxide, which rise and float in the air, from the combustion of zinc.*

Lampblack. The finest lampblack is produced by collecting the smoke from a lamp with a long wick, which supplies more oil than can be perfectly consumed, or by suffering the flame to play against a metalline cover, which impedes the combustion, not only by conducting off part of the heat, but by obstructing the current of air. Lampblack, however, is prepared in a much cheaper way, for the demands of trade. The dregs which remain after the eliquation of pitch, or else small pieces of fir-wood, are burned in furnaces of a peculiar construction, the smoke of which is made to pass through a long horizontal flue, terminating in a close boarded chamber. The roof of this chamber is made of coarse cloth, through which the current of air escapes, while the soot remains behind.

Lapis Infernalis. Potash.

Lapis Lazuli. Azure-stone.

Lapis Nephriticus. See **Nephrite.**

Lapis Ollaris. Potstone.

Lava. See **Volcanic Products.**

Lazuli. (Lapis). Azure-stone.

Lead, is a white metal of a considerably blue tinge, very soft and flexible, not very tenacious, and consequently incapable of being drawn into fine wire, though it is easily extended into thin plates under the hammer. Its sp. gr. is 11.35. It melts at 612°. In a strong heat it boils, and emits fumes; during which time, if exposed to the air, its oxidation proceeds with considerable rapidity. Lead is brittle at the time of congelation. In this state it may be broken to pieces with a hammer, and the crystallization of its internal parts will exhibit an arrangement in parallel lines.

Lead is not much altered by exposure to air or water, though the brightness of its surface, when cut or scraped, very soon goes off. It is probable that a thin stratum of oxide is formed on the surface, which defends the rest of the metal from corrosion.

* There are certainly two, perhaps three oxides of lead:

1. The powder precipitated by potash from the solution of the nitrate of lead, being dried, forms the yellow protoxide. When somewhat vitrified, it constitutes litharge, and combined with carbonic acid, white lead or ceruse. It has been obtained by M. Houton-Labillardiere, in dodecahedral white crystals, about the size of a pin-head, by slow deposition, from a solution of litharge in soda. Heat volatilizes it. It is of very great importance to know accurately the composition of this oxide of lead, especially in consequence of its great influence in the analyses of organic bodies. The mean of Berzelius's last experiments, as detailed in the 5th vol. of the *Afhandlingar i Fysik*, and translated into the Ann. of Phil. for February 1820, gives us 7.73 for the quantity of oxygen, combined with 100 of lead in 107.73 of the protoxide; whence the prime equivalent of lead comes out 12.9366. The very near approach of this to 13, will justify us in adopting this round number; and in estimating the equivalent of the protoxide at 14. The pigment massicot is merely this oxide.

2. When massicot has been exposed for about 48 hours to the flame of a reverberatory furnace, it becomes red-lead. or minium. This substance has a sp. gr. of 8.94. At a red heat, it gives out oxygen, and passes into vitrified protoxide. It consists of 100 lead + 11.08 oxygen; and it may be represented as a compound of 2 primes of

lead + 3 oxygen; or of 1 prime protoxide + 1 prime peroxide.

3. If upon 100 parts of red-lead, we digest nitric acid of the sp. gr. 1.26, 92.5 parts will be dissolved, but 7.5 of a dark-brown powder will remain insoluble. This is the peroxide of lead, and consists of 100 lead + 15.4 oxygen; or 13 + 2 = 15.

By passing a stream of chlorine through red-lead diffused in water, we obtain a solution, which yields by potash an abundant precipitate of the brown oxide of lead. From 100 of minium, 68 of the peroxide may be obtained. It is tasteless, and with muriatic acid evolves chlorine. When heated, oxygen is disengaged, and protoxide remains. The red-lead of commerce is often very impure, containing yellow oxide, sulphate of lead, submuriate of lead and silica.

Chloride of lead is formed, either by placing lead in chlorine, or by exposing the muriate to a moderate heat. It is a semitransparent grayish-white mass, somewhat like horn, whence the old name of *plumbum corneum*. It is fixed at a red heat in close vessels, but it evaporates at that temperature in the open air. By Dr. Davy's analysis, it consists of chlorine 25.78 + lead 74.22; or 4.5 + 13.

The iodide is easily formed, by heating the two constituents. It has a fine yellow colour. It precipitates when we pour hydriodate of potash into a solution of nitrate of lead.

The salts of lead have the protoxide for their base, and are distinguishable by the following general characters:—

1. The salts which dissolve in water, usually give colourless solutions, which have an astringent sweetish taste.

2. Placed on charcoal they all yield, by the blow-pipe, a button of lead.

3. Ferroprussiate of potash occasions in their solutions a white precipitate.

4. Hydrosulphuret of potash, a black precipitate.

5. Sulphuretted hydrogen, a black precipitate.

6. Gallic acid, and infusion of galls, a white precipitate.

7. A plate of zinc, a white precipitate, or metallic lead.

Most of the acids attack lead. The sulphuric does not act upon it, unless it be concentrated and boiling. Sulphurous acid gas escapes during this process, and the acid is decomposed. When the distillation is carried on to dryness, a saline white mass remains, a small portion of which is soluble in water, and is the sulphate of lead; it affords crystals. The residue of the white mass is an insoluble sulphate of lead. * It consists of 5 acid + 14 protoxide.*

Nitric acid acts strongly on lead.

*The nitric solution, by evaporation, yields tetrahedral crystals, which are white, opaque, possess considerable lustre, and have a sp. gr. of 4. They dissolve in 7.6 parts of boiling water. They consist of 6.75 acid + 14 protoxide; or nearly 1 + 2.

A *subnitrate* may be formed in pearl coloured scales, by boiling in water, equal weights of the nitrate and protoxide.

A subnitrite of lead may be formed, by boiling a solution of 10 parts of the nitrate, on 7.8 of metallic lead. If more of the metal be used, a quadro-subnitrite results. By saturating one-half of the oxide of the subnitrite, with the equivalent proportion of sulphuric acid, a neutral nitrite is formed.*

Muriatic acid acts directly on lead by heat, oxidizing it and dissolving part of its oxide.

The acetic acid dissolves lead and its oxides; though probably the access of air may be necessary to the solution of the metal itself in this acid. *White lead*, or *ceruse*, is made by rolling leaden plates spirally up, so as to leave the space of about an inch between each coil, and placing them vertically in earthen pots, at the bottom of which is some good vinegar. The pots are to be covered, and exposed for a length of time to a gentle heat in a sand-bath, or by bedding them in dung. The vapour of the vinegar, assisted by the tendency of the lead to combine with the oxygen which is present, corrodes the lead, and converts the external portion into a white substance, which comes off in flakes, when the lead is uncoiled. The plates are thus treated repeatedly, until they are corroded through. Ceruse is the only white used in oil paintings. Commonly it is adulterated with a mixture of chalk in the shops. It may be dissolved without difficulty in the acetic acid, and affords a crystallizable salt, called *sugar of lead* from its sweet taste. This, like all the preparations of lead, is a deadly poison. The common sugar of lead is an acetate; and Goulard's extract, made by boiling litharge in vinegar, a subacetate. The power of this salt, as a coagulator of mucus, is superior to the other. If a bit of zinc be suspended by brass or iron wire, or a thread, in a mixture of water and the acetate of lead, the lead will be revived, and form an arbor Saturni.

* The acetate, or sugar of lead, is usually crystallized in needles, which have a silky appearance. They are flat four-sided prisms with dihedral summits. Its sp. gr. is 2.345. It is soluble in three and a half times its weight of cold water, and in somewhat less of boiling water. Its constituents are 26.96 acid + 58.71 base + 14.32 water.—*Berzelius.*

The subacetate crystallizes in plates, and is composed of 13.23 acid + 86.77 base; or 1 prime + 3. In the extensive and excellent sugar of lead works of Mr. Mackintosh, and of Mr. Ramsay, at Glasgow, this salt is occasionally formed in large flat rhomboidal prisms, which Dr. Thomson supposes to consist of five atoms oxide of lead, four atoms acetic acid, and 19 atoms water; while he considers the ordinary acetate as a compound of one atom acid, one atom oxide, and three atoms water. The sulphuret, sulphate, carbonate, phosphate, arseniate, and chromate of lead, are found native, and will be described among its ORES.

When lead is alloyed with an equal weight of tin, or perhaps even less, it ceases to be acted on by vinegar. Acetate and subacetate of lead in solution, have been used as external applications to inflamed surfaces, and scrofulous sores, and as eyewashes. In some extreme cases of hæmorrhagy from the lungs and bowels, and uterus, the former salt has been prescribed, but rarely and in minute doses, as a corrugant or astringent. The colic of the painters, and that formerly prevalent in certain counties of England, from the lead used in the cyder presses, show the very deleterious operation of the oxide, or salts of this metal, when habitually introduced into the system in the minutest quantities at a time. Contraction of the thumbs, paralysis of the hand, or even of the extremities, have not unfrequently supervened. A course of sulphuretted hydrogen waters, laxatives, of which sulphur, castor-oil, sulphate of magnesia, or calomel, should be preferred, a mercurial course, the hot sea-bath, and electricity, are the appropriate remedies.

Dealers in wines have occasionally sweetened them when acescent, with litharge or its salts. This deleterious adulteration may be detected by sulphuretted hydrogen water, which will throw down the lead in the state of a dark brown sulphuret. Or subcarbonate of ammonia, which is a more delicate test, may be employed to precipitate the lead in the state of a white carbonate; which, on being washed and digested with sulphuretted hydrogen water, will instantly become black. If the white precipitate be gently heated, it will become yellow, and, on charcoal before the blowpipe, it will yield a globule of lead. Chromate of potash, will throw down from saturnine solutions, a beautiful orange-yellow powder. Burgundy wine, and all such as contain tartar, will not hold lead in solution, in consequence of the insolubility of the tartrate.

The proper counter-poison for a dangerous dose of sugar of lead, is solution of Epsom or Glauber salt, liberally swallowed; either of which medicines instantly converts the poisonous acetate of lead into the inert and innoxious sulphate. The sulphuret of potash, so much extolled by Navier, instead of being an antidote, acts itself as a poison on the stomach.*

Oils dissolve the oxide of lead, and become thick and consistent; in which state they are used as the basis of plasters, cements for water-works, paints, &c.

Sulphur readily dissolves lead in the dry way, and produces a brittle compound, of a deep gray colour and brilliant appearance, which is much less fusible than lead itself; a property which is common to all the combinations of sulphur with the more fusible metals.

The phosphoric acid, exposed to heat together with charcoal and lead, becomes converted into phosphorus, which combines with the metal. This combination does not greatly differ from ordinary lead; it is malleable, and easily cut with a knife; but it loses its brilliancy more speedily than pure lead; and when fused upon charcoal with the blow-pipe, the phosphorus burns, and leaves the lead behind.

Litharge fused with common salt decomposes it; the lead unites with the muriatic acid, and forms a yellow compound, used as a pigment. The same decomposition takes place in the humid way, if common salt be macerated with litharge; and the solution will contain caustic alkali.

Lead unites with most of the metals. Gold and silver are dissolved by it in a slight red heat. Both these metals are said to be rendered brittle by a small admixture of lead, though lead itself is rendered more ductile by a small quantity of them. Platina forms a brittle compound with lead; mercury amalgamates with it; but the lead is separated from the mercury by agitation, in the form of an impalpable black powder, oxygen being at the same time absorbed. Copper and lead do not unite but with a strong heat. If lead be heated so as to boil and smoke, it soon dissolves pieces of copper thrown into it; the mixture, when cold, is brittle. The union of these two metals is remarkably slight; for, upon exposing the mass to a heat no greater than that in which lead melts, the lead almost entirely runs off by itself. This process is called eliquation. The coarser sorts of lead, which owe their brittleness and granulated texture to an admixture of copper, throw it up to the surface on being melted by a small heat. Iron does not unite with lead, as long as both substances retain their metallic form. Tin unites very easily with this metal, and forms a compound, which is much more fusible than lead by itself, and is, for this reason, used as a solder for lead. Two parts of lead and one of tin, form an alloy more fusible than either metal alone: this is the solder of the plumbers. Bismuth combines readily with lead, and affords a metal of a fine close grain, but very brittle. A mixture of eight parts bismuth, five lead, and three tin, will melt in a heat which is not sufficient to cause water to boil. Antimony forms a brittle alloy with lead. Nickel, cobalt, manganese, and zinc, do not unite with lead by fusion.

All the oxides of lead are easily revived with heat and carbon.

Leather. The skins of animals prepared by maceration in lime water, and afterward with astringent substances. See Tanning.

* Leaves of Plants. See Chlorophyle.*

Lees (Soap). See Potash; also Soap.

Lemons. See Acid (Citric).

* Lemnian Earth, or Sphragide. Colour yellowish-gray, and frequently marbled with rusty spots. Dull. Fracture fine earthy. Meagre to the feel. Adheres slightly to the tongue. When plunged in water, it falls to pieces with disengagement of air-bubbles. Its constituents are, 66 silica, 14.5 alumina, 0.25 magnesia, 0.25 lime, 3.5 soda, 6 oxide of iron, 8.5 water.—*Klaproth.* It has hitherto been found only in the Island of Stalimene, (ancient Lemnos). It is reckoned a medicine in Turkey; and is dug up only once a year, with religious solemnities, cut into spindle-shaped pieces, and stamped with a seal. It was esteemed an antidote to poison and the plague in Homer's time; a virtue to which it has not the slightest claim.*

* Lepidolite. Colour peach-blossom red, sometimes gray. Massive, and in small concretions. Lustre glistening, pearly. Cleavage single. Fracture, coarse splintery. Feebly translucent. Soft. Rather sectile. Rather easily frangible. Sp. gr. 2.6 to 2.8. It intumesces before the blow-pipe, and melts easily into a milk-white translucent globule. Its constituents are 54 silica, 20 alumina, 18 potash, 4 fluate of lime, 3 manganese, and 1 iron.—*Vauquelin.* It occurs in limestone at Dalmally, and on the north side of Lochfine; on the east side of Loch-leven, nearly opposite the Inn at Balachulish. It is found in many places on the continent. On account of its beautiful colour, it has been cut into snuff-boxes, but it is rather soft and greasy to the aspect.—*Jameson.*

* Leucite. Dodecahedral zeolite of Jameson. Colour white, whence its name. Generally in roundish imbedded grains, or crystallized in acute double eight-sided pyramids. Internal lustre shining. Cleavage imperfect. Fracture imperfect conchoidal. Translucent. Refracts single. Harder than apatite, but softer than feldspar. Brittle. Sp. gr. 2.5. With borax it fuses into a brownish transparent glass. Its constituents are 56 silica, 20 alumina, 20 potash, 2 lime, and 2 loss.—*Vauquelin.* It is almost peculiar to Italy, occurring in trap-rocks and lavas, at Albano, Frascati, and near Naples.*

* Libavius, smoking liquor of: deutochloride of tin.*

Levigation. The mechanical process of grinding the parts of bodies to a fine paste, by rubbing the flat face of a stone called the muller, upon a table or slab called the stone. Some fluid is always added in this process. The advantage of levigation with a stone and muller, beyond that of triturating in a mortar, is, that the materials can more easily be scraped together, and subjected to the action of the muller, than in the other case to that of the pestle; and, from the flatness of the two surfaces, they cannot elude the pressure.

* Lievrite or Yenite. Colour black. Massive; in distinct concretions; and crystallized in oblique or almost rectangular four-sided prisms, varying from acicular to the thickness of an inch. Lateral planes longitudinally streaked. Lustre glistening, semi-metallic. Fracture uneven. Opaque. Scratches glass, and gives a few sparks with steel, but is scratched by adularia. Streak unchanged. Easily frangible. Sp. gr. 3.9. Magnetic on being heated; its colour at the same time changing to reddish-brown. It melts into an opaque black bead, having a metallic aspect, and magnetic. Its constituents are 30 silica, 12.5 lime, 57.5 oxide of iron and oxide of manganese, the last of which forming only 2 or 3 parts. It occurs in primitive limestone in the island of Elba.*

* Light. The agent of vision.

Some philosophers regard light as consisting of particles of inconceivable minuteness, emitted in succession by luminous bodies, which move in straight lines, at the rate of 200,000 miles per second.

Others conceive that it consists in certain undulations communicated by luminous bodies, to an etherial fluid which fills all space. This fluid is composed of the most subtile matter, is highly elastic, and the undulations are propagated through it with great velocity, in spherical superficies proceeding from a centre. This view derives great plausibility from its happy application by Huygens, to explain a very difficult class of optical phenomena, the double refraction of calcareous spar and other bodies.

The *common* refraction is explained by Huygens on the supposition, that the undulations in the luminous fluid are propagated in the form of *spherical* waves. The *double* refraction is explained on the supposition, that the undulations of light, in passing through the calcareous spar, assume a *spheroidal* form; and this hypothesis, though it does not apply with the same simplicity as the former, yet admits of such precision, that a proportion of the axes of the spheroids may be assigned, which will account for the precise quantity of the extraordinary refraction, and for all the phenomena dependent on it, which Huygens had studied with great care, and had reduced to the smallest number of general facts.

"That these spheroidal undulations actually exist," says the celebrated Playfair, "he would after all be a bold theorist who should affirm; but that the supposition of their existence is an accurate expression of the phenomena of double refraction, cannot be doubted. When one enunciates the hypothesis of the spheroidal undulations, he in fact expresses in a single sentence all the phenomena of double refraction. The hypothesis is therefore the means of representing these phenomena, and the laws which they obey, to the imagination or the understanding; and there is perhaps no theory in optics, and but very few in natural philosophy, of which more can be said. Theory therefore, in this instance, is merely to be regarded as the expression of a general law, and in that light I think it is considered by La Place."

Dr. Young has selected from Sir Isaac Newton's various writings, many passages favourable to the admission of the undulatory theory of light, or of a luminiferous ether pervading the universe, rare and elastic in a high degree. "Is not the heat (of the warm room) conveyed through the vacuum by the vibrations of a much subtiler medium than air? And is not this medium the same with that medium by which light is reflected and refracted, and by whose vibrations light communicates heat to bodies, and is put into fits of easy reflection and easy transmission? And do not the vibrations of this medium in hot bodies contribute to the intenseness and duration of their heat? And do not hot bodies communicate their heat to contiguous cold ones, by the vibrations of this medium, propagated from them into the cold ones? And is not this medium exceedingly more rare and subtile than the air, and exceedingly more elastic and active? And doth it not readily pervade all bodies? And is it not by its elastic force expanded through all the heavens?"—"If any one would ask how a medium can be so rare, let him tell me how an electric body can by friction emit an exhalation so rare and subtile, and yet so potent? And how the effluvia of a magnet can pass through a plate of glass without resistance, and yet turn a magnetic needle beyond the glass?"—*Optics, Qu.* 18. 22. "Were I to assume an hypothesis, it should be this, if propounded more generally, so as not to determine what light is, farther than that it is something or other capable of exciting vibrations in the ether; for thus it will become so general, and comprehensive of other hypothesis, as to leave little room for new ones to be invented."—*Birch*, iii. 249.

Dr. Young shows, that many phenomena inexplicable on the notion of radiating corpuscles, are easily reconciled to the theory of undulation. "On the whole," says this profound philosopher, "it appears that the few optical phenomena, which admit of explanation by the corpuscular system, are equally consistent with this theory; that many others which have been long known, but never understood, become by these means perfectly intelligible; and that several new facts are found to be thus, only, reducible to a perfect analogy with other facts, and to the simple principles of the undulatory system."—*Nat. Phil.* vol. ii. p. 631.

I think, however, that the new discoveries on polarized light may be more easily referred to the corpuscular than undulatory hypothesis.

The physical affections of light are foreign to this work. Its chemical relations are alone to be considered. These may be conveniently referred to four heads:—

1. Of the mean refractive and dispersive powers of different bodies.

2. Of the action of the different prismatic colours on chemical matter.

3. Of the polarization of light.

4. Of the absorption and disengagement of light, or phosphorescence.

1. Newton first discovered that certain bodies exercise on light a peculiar attractive force. When a ray passes obliquely from air into any transparent liquid or solid surface, it undergoes at entrance an angular flexure, which is called *refraction*. The variation of this departure from the rectilineal path for any particular substance, depends on the obliquity of the ray to the refracting surface; so that the sine of the angle of refraction, is to that of the angle of incidence, in a constant ratio. Now Newton found that unctuous or inflammable bodies occasioned a greater deviation in the luminous rays than their attractive mass or density gave reason to expect. Hence he conjectured, that both diamond and water contained combustible matter,—a sagacious anticipation of future chemical discovery.

Dr. Wollaston invented a very ingenious apparatus, in which, by means of a rectangular prism of flint glass, the index of refraction of each substance is read off at once by a vernier, the three sides of a moveable triangle performing the operations of reduction, in a very compendious manner.—*Phil. Trans.* 1802, or *Nicholson's Journal*, 8vo. vol. iv. p. 89.

But transparent media occasion not merely a certain flexure of the white sunbeam, called the *mean refraction*, they likewise decompose it into its constituent colours. This effect is called *dispersion*. Now the mean refractive and dispersive powers of bodies are not proportional to each other. In some refracting media, the mean angle of refraction is larger, whilst the angle of dispersion is smaller; and in other refracting media, the mean angle of refraction is smaller, whilst the angle of dispersion is larger. In short, the knowledge of the mean refractive power of a given substance, will not enable us to determine its dispersive power, and *vice versa*.

From the refractive power of bodies we may in many cases infer their chemical constitution. For discovering the purity of essential oils, an examination with Dr. Wollaston's instrument may be of considerable utility, on account of the smallness of the quantity requisite for trial. "In oil of cloves, for instance, I have met with a wide difference. The refractive power of genuine oil of cloves is as high as 1.535; but I have also purchased oil by this name which did not exceed 1.498, and which had probably been adulterated by some less refractive oil." This fine idea, suggested by Dr. Wollaston, has been happily prosecuted by M. Biot, with regard to gaseous compounds. I shall first give general tables of the refractive and dispersive powers of different bodies, and then make some remarks on their chemical applications:—

		Index of Refraction.
A vacuum,		1.00000
Atmospheric air, (mean,)		1.00033
Ice,	Wol.	1.31000
Ice,	Brewster,	1.30700
Water,		1.336
Vitreous humour,	Cryolite. B.	1.344
Ether,	W.	1.358
Albumen,	W.	1.360
Alcohol,	W.	1.370
Saturated solut. of salt,	Cavallo,	1.375
Solution of sal ammoniac,		1.382
Nitric acid, sp. gr. 1.48,	W.	1.410
Fluor spar,	W.	1.433
Sulphuric spar,	W.	1.435
Spermaceti, melted,	W.	1.446
Crystalline lens of an ox,	W.	1.447
Alum,	W.	1.457
Tallow melted,	W.	1.460
Borax,	C.	1.467
Oil of lavender,	W.	1.467
	C.	(1.469)
Oil of peppermint,	W.	1.468
Oil of olives,	W.	1.469
Oil of almonds,	W.	1.470
Oil of turpentine, rectified,	W.	1.470
Do. common,	W.	1.476
Essence of lemon,	W.	1.476
Butter, cold,	W.	1.480
Linseed oil,	W.	1.485
Camphor,	W.	1.487
Iceland spar, weakest refr.	W.	1.488
Do. strongest do.	W.	(1.657)
Tallow, cold,	W.	1.49
Sulphate of potash,	W.	1.495
Oil of nutmeg,	W.	1.497
French plate-glass,	W.	1.500
English plate-glass	W.	1.504
Oil of amber,	W.	1.505
Balsam of capivi,	W.	1.507
Gum-arabic,	W.	1.514
Dutch plate-glass,	W.	1.517
Caoutchouc,	W.	1.524
Nitre,	C.	1.524
Selenite,	W.	1.525
Crown glass, common,	W.	1.525
Canada balsam,	W.	1.528
Centre of the crystalline of fish, and dry crystalline of an ox,	W.	1.530
Pitch,	W.	
Radcliffe crown-glass,	W.	1.533
Animé,	W.	1.535
Copal,	W.	1.535
Oil of cloves,	W.	1.535
White wax cold, Elemi, Mastic, Arseniate of potash, Sugar after fusion, Spermaceti cold, Red sealing-wax,	W.	
Oil of sassafras,	W.	1.536
Bees-wax,	W.	1.542
Boxwood,	W.	
Colophony,	W.	1.543
Old plate-glass,	W.	1.545
Rock crystal, (double),	W.	1.547
Amber,	W.	1.547
	C.	(1.556)
Opium,	W.	
Mica,	W.	
Phosphorus,	W.	1.579
Horn,	W.	
Flint-glass,	W.	1.583 1.586
Benzoin,	W.	
Guaiacum,	W.	1.596
Balsam of Tolu,	W.	1.600
Sulphate of baryt. (double R.)	W.	1.646
Iceland spar, (strongest),	W.	1.657
Gum dragon,	W.	
Carburet of sulphur,	Br.	1.680
White sapphire,	W.	1.768
Muriate of antimony, variable,	W.	
Arsenic, (a good test),	W.	1.811
Spinelle ruby,	W.	1.812
Jargon,	W.	1.950
Glass of antimony,	W.	1.980
Native sulphur,	W.	2.040
Do.	Brewster,	2.115
Plumbago,	W.	
Phosphorus,	Brewster,	2.224
Diamond,	Newton, by Dr. W.	2.440
Do.	Rochon,	2.755
Realgar,	Brewster,	2.510
Chromate of lead, (least refr.),	do.	2.479
Do. (greatest refr.)	do.	2.926

TABLE II.—*Refracting Powers of Gases for the temperature of* 32° *F. and pressure* 30, *by MM. Biot and Arago.*

Atmospheric air, - -	1.00000
Oxygen, - - - -	0.86161
Azote, - - - - -	1.03408
Hydrogen, - - - -	6.61436
Ammonia, - - - -	2.16851
Carbonic acid, - - - -	1.00476
Subcarburetted hydrogen, -	2.09270
Muriatic acid gas, - -	1.19625

TABLE III.—*Dispersive Powers.*

Cryolite,	Brewster,	0.022
Fluor spar,	do.	0.022
Water,	do.	0.035
Diamond,	do.	0.038
Flint glass, (highest),	do.	0.052
Carburet of sulphur,	do.	0.115
Phosphorus,	do.	0.128
Sulphur,	do.	0.130
Oil of cassia,	do.	0.139
Realgar,	do.	0.255
Chromate of lead, (least refr.)	do.	0.262
Do. (greatest refr.)	do.	0.400

Carburet of sulphur exceeds all fluid bodies in refractive power, surpassing even flint-glass, topaz, and tourmaline; and in dispersive power it exceeds every fluid substance, except oil of cassia, holding an intermediate place between phosphorus and balsam of Tolu.

Dr. Brewster has further shown, that all doubly refracting crystals have two dispersive powers.

From Table II. it appears, that the refractive power of hydrogen gas greatly surpasses not only that of the other gases, but of all known bodies. This principle exists in great abundance, in resins, oils, and gums, where it is united to carbon and oxygen; and we must probably ascribe to it, the eminent refractive power of these combustibles, so justly observed by Newton. This effect of hydrogen is finely displayed in ammonia, whose refractive power is more than double that of air; and much superior to that of water.

But since every substance ought to introduce into its combinations, its peculiar character, and preserve in them to a certain degree, the force with which it acts on light, let us endeavour to calculate in this point of view, the refractive influence of the constituents of a compound. From our knowledge of the extreme tenuity of light, it is probable, that the influence of a moderate chemical condensation, ought to affect its operations very slightly; for whether it be an ether or a corpuscular emanation, the excessive minuteness of its particles, compared to the distances between the molecules of bodies, ought to render the change of distance among the latter, unimportant. Consequently, the refracting powers of bodies ought to differ very little from those of their elements, unless a very great degree of condensation has taken place.

Hence, if we multiply the proportions of azote and oxygen respectively, by their refractive powers, we shall obtain products, whose sums will coincide with the refractive power of the atmosphere. Thus, 100 parts by weight of the atmosphere, consist of azote 77.77 + oxygen 22.22. If we multiply each of these numbers by the number representing the refractive power of the body, and making a small correction for the carbonic acid present, we shall have for the sum of the products 1.0000.

Ammonia, however, furnishes a more interesting example of the application of these principles.

The refractive power

of hydrogen is,	6.61436
of azote,	1.03408
of ammonia,	2.16851

Let x be the weight of the constituent, whose refractive power is, a
$y = 100 - x =$ that whose power is b
and call the refractive power of the compound, c

Then $x = \dfrac{c-b}{a-b}$. In the present case,

$$x = \frac{2.16851 - 1.03408}{6.61436 - 1.03408} = 0.203$$

and $100 - x = 0.797 =$ the azote in 100 parts of ammonia; which may be regarded as an approximation. The true proportions given by the equivalent ratios are, 0.823 azote + 0.177 hydrogen. If the refractive power of ammonia were 2.0218, then the chemical and optical analysis would coincide.

If we calculate on the above data, what ought to be the refractive power of water, as a compound of 8 parts of oxygen + 1 hydrogen, we shall obtain the number 1.50065, which being multiplied by 0.45302, the absolute refractive power of air, when we take the density of water for unity, we shall have a product = 0.67984. Now, according to Newton's estimate, which M. Biot has found to be exact, the refractive power of water is 0.7845. Hence, we see, that the compound has acquired an increased refractive force by condensation, above the mean of its constituents, in the ratio of 100 to $86\frac{2}{3}$.

Rays of light, in traversing the greater number of crystallized bodies, are commonly split into two pencils; one of which, called the ordinary ray, follows the common laws of refraction, agreeably to the preceding tables, whilst the other, called the extraordinary ray, obeys very different laws. This phenomenon is produced in all transparent crystals, whose primitive form is neither a cube nor a regular octohedron. The division of the beam is greater or less, according to the nature of the crystal, and the direction in which it is cut. But of all known substances, that which produces this phenomenon in the most energetic manner, is the rhomboidal carbonate of lime commonly called iceland spar.

2. Of the action of the different *coloured* rays. If the white sunbeam, admitted through a small hole of a window-shutter into a darkened room, be made to pass through a triangular prism of glass, it will

be divided into a number of splendid colours which may be thrown upon a sheet of paper. Newton ascertained, that if this coloured image, or spectrum as it is called, be divided into 360 parts, the red will occupy 45, the orange 27, the yellow 48, the green 60, the blue 60, the indigo 40, and the violet 80. The red rays being least bent by the prism, from the direction of the white beam, are said to be least refracted or the least refrangible; while the violet rays being always at the other extremity of the spectrum, are called the most refrangible. According to Dr Wollaston, when the beam of light is only 1-20th of an inch broad, and received by the eye at the distance of 10 feet, through a clear prism of flint-glass, only four colours appear; red, yellowish-green, blue, and violet.

If the differently coloured rays of light thus separated by the prism, be concentred on one spot by a lens, they will reproduce colourless light. Newton ascribes the different colours of bodies, to their power of absorbing all the primitive colours, except the peculiar one which they reflect, and of which colour they therefore appear to our eye.

According to Sir William Herschel, the different coloured rays possess very different powers of illumination. The lightest green, or deepest yellow, which are near the centre, throw more light on a printed page than any of the rays towards either side of the spectrum. Sir H. Davy remarks, that as there are *more* green rays in a given part of the sprectrum than blue rays, the difference of illuminating power may depend on this circumstance. The rays separated by one prism, are not capable of being further divided by being passed through another; and in their relations to double refraction and reflection, they appear to agree with direct light. An object illuminated by any of the rays in the spectrum, is seen double through iceland crystal, in the same manner as if it had been visible by white light.

Under Caloric, we have stated the power of heating which the different coloured rays of the spectrum apparently possess. Sir H. Englefield, and M. Berard, confirmed the results of Sir W. Herschel, with regard to the progressive increase of calorific influence from the violet to the red extremity of the spectrum; and they also found with him, that a calorific influence extended beyond the limit of the red light, into the unilluminated space. M. Berard, however, observed, that the maximum of effect was *in* the light, and not *beyond* it. This ingenious philosopher made a pencil of the sunbeam pass across a prism of iceland spar. The division of the rays formed two *spectra*, which presented the same properties with the single spectrum. Both possessed the calorific virtue in the same manner and degree. M. Berard polarized a beam of light by reflection from a mirror; and he found that in all the positions in which light ceased to be reflected, heat also ceased to appear. The thermometer in the focus of the apparatus was no longer affected. Thus, we see, that the obscure heat-making principle, accompanies the luminous particles, and obeys the same laws of action.

If the white *luna cornea*, the muriate of silver moistened, be exposed to the different rays in the prismatic spectrum, it will be found, that no effect is produced upon it, in the least refrangible rays, which occasion heat without light; that only a slight discoloration will be occasioned by the red rays; that the blackening power will be greater in the violet than in any other ray; and that beyond the violet, in a space perfectly obscure to our eyes, the darkening effect will be manifest on the muriate.

This fine observation, due to M. Ritter and Dr. Wollaston, proves, that there are rays more refrangible than the rays producing light and heat. As it appears, from the observations of M. Berthollet, that muriatic acid gas is formed when horn-silver is blackened by light, the above rays may be called hydrogenating. Sir H. Davy found, that a mixture of chlorine and hydrogen acted more rapidly upon each other, combining without explosion, when exposed to the red rays, than when placed in the violet rays; but that solution of chlorine in water became solution of muriatic acid most rapidly, when placed in the most refrangible rays in the spectrum. He also observed, that the puce-coloured oxide of lead, when moistened, gradually gained a tint of red in the least refrangible rays. and at last became black, but was not affected in the most refrangible rays. The same change was produced by exposing it to a current of hydrogen gas. The oxide of mercury from calomel and water of potash, when exposed to the spectrum, was not changed in the most refrangible rays, but became red in the least refrangible, which must have been owing to the absorption of oxygen. The violet rays produced upon moistened red oxide of mercury, the same effect as hydrogen gas.

Dr. Wollaston found, that guaiac, exposed to the violet rays, passed rapidly from yellow to green; and MM. Gay-Lussac and Thenard applied to the same influence a gaseous mixture of hydrogen and chlorine, when explosion immediately took place. By placing small bits of card, coated with moist horn-silver, or little phials of those mixed gases, in the different parts of the spectrum, M. Berard verified the former observations of the chemical power acquiring a maximum in the violet ray, and existing even beyond it; but he also found, that by leaving the tests a sufficient time in the indigo and blue rays, a perceptible effect was produced upon them. He concentrated by a lens all that portion of the spectrum which extends from the green to the extreme boundary of the violet; and by another lens he collected the other half of the spectrum, comprehending the red. The latter formed the focus of a white light, so brilliant, that the eye could not endure it; yet in two hours it produced no sensible change on muriate of silver. On the contrary, the focus of the other half of the spectrum, whose light and heat were far less intense, blackened the muriate in ten minutes. The investigations of Delaroche enable us, in some measure, to reduce these dissimilar effects of light to a common principle. See Caloric.

In Mr Brande's late Bakerian lecture on the composition and analysis of coal and oil gases, this ingenious chemist shows, that the light produced by these, or by olefiant gas, even when concentrated so as to produce a sensible degree of heat, occasioned no change on the colour of muriate of silver, nor on a mixture of chlorine and hydrogen; while the light emitted by electrized charcoal, speedily affects the muriate, causes these gases to unite rapidly, and sometimes with explosion. The concentrated light of the moon, like that of the gases, produced no change. He concludes with stating, that he found the photometer of Mr. Leslie ineffectual. He employed one filled with the vapour of ether (renewable from a column of that fluid), which he found to be more delicate.

The general facts, says Sir H. Davy, of the refraction and effects of the solar beam, offer an analogy to the agencies of electricity. In the voltaic circuit, the maximum of heat seems to be at the positive pole, where the power of combining with oxygen is given to bodies, and the agency of rendering bodies inflammable is exerted at the opposite surface; and similar chemical effects are produced by negative electricity, and by the most refrangible rays of the solar beam. In general, in nature, the effects of the solar rays are very compounded. Healthy vegetation depends upon the presence of the solar beams, or of light; and whilst the heat gives fluidity and mobility to the vegetable juices, chemical effects likewise are occasioned, oxygen is separated from them, and inflammable compounds formed. Plants deprived of light become white, and contain an excess of saccharine and aqueous particles; and flowers owe the variety of their hues to the influence of the solar beams. Even animals require the presence of the rays of the sun, and their colours seem materially to depend upon the chemical influence of these rays; a comparison between the polar and tropical animals, and between the parts of their bodies exposed, and those not exposed to light, shows the correctness of this opinion.

III. *Polarization of Light.*

This new branch of optical science, sprung from the ingenuity of Malus. It has been since cultivated chiefly by M. Biot in France, and by Dr. Brewster in this kingdom. I am happy to observe, that Mr. Herschel has lately entered the lists under very favourable auspices.

If a solar ray fall on the anterior surface of an unsilvered mirror plate, making an angle with it of 35° 25′, the ray will be reflected in a right line, so that the angle of reflection will be equal to the angle of incidence. In any point of its reflected path, receive it on another plane of similar glass, it will suffer in general a second partial reflection. But this reflection will vanish, or become null, if the second plate of glass form an angle of 35° 25′ with the first reflected ray, and at the same time be turned, so that the second reflection is made in a plane perpendicular to that in which the first reflection takes place. For the sake of illustration, suppose that the plane of incidence of the ray on the first glass, coincides with the plane of the meridian, and that the reflected ray is vertical. Then, if we make the second inclined plate revolve, it will turn around the reflected ray, forming always with it the same angle; and the plane in which the second reflection takes place, will necessarily be directed towards the different points of the horizon, in different azimuths. This being arranged, the following phenomena will be observed.

When the second plane of reflection is directed in the meridian, and consequently coincides with the first, the intensity of the light reflected by the second glass is at its maximum.

In proportion as the second plane, in its revolution, deviates from its parallelism with the first, the intensity of the reflected light will diminish.

Finally, when the second plane of reflection is placed in the prime vertical, that is east and west, and consequently perpendicular to the first, the intensity of the reflection of light is absolutely null on the two surfaces of the second glass, and the ray is entirely transmitted.

Preserving the second plate at the same inclination to the horizon, if we continue to make it revolve beyond the quadrant now described, the phenomena will be reproduced in the inverse order; that is, the intensity of the light will increase, precisely as it diminished, and it will become equal, at equal distances from the east and west. Hence, when the second plane of reflection returns once more to the meridian, a second maximum of intensity equal to the first recurs.

From these experiments it appears, that the ray reflected by the first glass, is not reflected by the second, under this incidence, when it is presented to it by its east and west sides; but that it is reflected, at least in part, when it is presented to the glass by any two others of its opposite sides. Now if we regard the ray as an infinitely rapid succession of a series of luminous particles, the faces of the ray are merely the successive faces of these particles. We must hence conclude, that these particles possess faces endowed with different physical properties, and that in the present circumstance, the first reflection has turned towards the same sides of space, similar faces, or faces equally endowed at least with the property under consideration. It is this arrangement of its molecules which Malus named the *polarization* of light, assimilating the effect of the first glass to that of a magnetic bar, which would turn a series of magnetic needles, all in the same direction.

Hitherto we have supposed that the ray, whether incident or reflected, formed with the two mirror plates, an angle of 35° 25′; for it is only under this angle that the phenomenon is complete. Without changing the inclination of the ray to the first plate, if we vary never so little the inclination of the second, the intensity of the reflected light is no longer null in any azimuth, but it becomes the feeblest possible in the prime vertical, in which it was formerly null.

Similar phenomena may be produced by substituting for the mirror glasses, polished plates, formed for the greater part of transparent bodies. The two planes of reflection must always remain rectangular, but they must be presented to the luminous ray, at different angles, according to their nature. Generally, all polished surfaces have the property of thus polarizing, more or less completely, the light which they reflect under certain incidences; but there is for each of them a particular incidence, in which the polarization it impresses is most complete, and for a great many, it amounts to the whole of the reflected light.

When a ray of light has received polarization in a certain direction, by the processes now described, it carries with it this property into space, preserving it without perceptible alteration, when we make it traverse perpendicularly a considerable mass of air, water, or any substance possessed of single refraction. But the substances which exercise double refraction, in general alter the polarization of the ray, and apparently in a sudden manner, and communicate to it a new polarization of the same nature, but in another direction. It is only in certain directions of the principal section, that the ray can escape this disturbing force. The following may be regarded as the most general view of this subject.

When the particles of light pass through a crystallized body, endowed with double refraction, they experience different movements round their centre of gravity, which depend on the nature of the forces which the particles of the crystal exercise on them. Sometimes the effect of these forces is limited to the above *polarization*, or to the arranging all the particles of one ray, parallel to each other, so that their homologous faces are turned towards the same parts of space. When this disposition occurs, the luminous molecules preserve it, in the whole extent of the crystal, and experience no more movement around their centre of gravity. But there exists other cases, in which the molecules that traverse the crystal are not fixed in any constant position. During the time of their passage, they oscillate round their centre of gravity, with velocities and according to periods, which may be calculated. Lastly, they sometimes revolve round their own axes, with an uninterrupted movement of rotation. The former is called *fixed* polarization, the latter *moveable*.

In the Phil. Trans. for 1813, we have the first of a series of very interesting papers on polarized light by Dr. Brewster. This relates chiefly to some curious properties of agate. The plate of agate which he employed, was bounded by parallel faces, was about the fifteenth of an inch thick, and was cut into a plane, perpendicular to the laminæ, of which it was composed. When the image of a taper reflected from water at an angle of 52° 45′, so as to acquire the property discovered by Malus, was viewed through the plate of agate, so as to have its laminæ parallel to the plane of reflection, the flame appeared perfectly distinct, but when the agate was turned round, so that its laminæ became perpendicular to the plane of reflection, the light which formed the image of the taper suffered total reflection, and not one ray of it penetrated the agate. If a ray of light incident upon one plate of agate is received, after transmission, upon another plate of the same substance, having its laminæ parallel to those of the former, the light will find an easy passage through the second plate; but if the second plate has its laminæ perpendicular to those of the first, the light will be wholly reflected, and the luminous object will cease to be visible.

In a second important communication in 1814 on the affections of light transmitted through crystallized bodies, after suggesting that the cultivation of this department of physics may enable us to explain the forms and structure of crystallized bodies, a prediction which he himself has since happily fulfilled, the Doctor states, that if the light polarized by agate, is incident at a particular angle upon any transparent body, so that the plane of reflection is perpendicular to the laminæ of the agate, it will experience a total *refraction;* if it is transmitted through another plate of agate, having its laminæ at right angles to those of the plate by which the light is polarized, it will suffer total *reflec-*

tion; and if it is examined by a prism of Iceland crystal, turned round in the hand of the observer, it will vanish and reappear in every quadrant of its circular motion. The pencil of rays to which this remarkable property is communicated, is surrounded by a large mass of nebulous light, which extends about 7° 30′ in length, and 1° 7′ in breadth on each side of the bright image. This nebulous light never vanished with the bright image which it enclosed, but was obviously affected with its different changes, increasing in magnitude as the bright image diminished, and diminishing as the bright image regained its lustre. Light polarized by the agate, or by any other means, is depolarized, or partly restored to its original state, by being transmitted in a particular direction through a plate of mica, or any other crystallized body.

IV. *Of the Production of Light.*

Some philosophers refer the origin of all luminous phenomena to the sun, whose beams are supposed to penetrate, and combine with, the different forms of terrestrial matter. But we learn from Scripture, that light pre-existed before this luminary, and that its subsequent condensation in his orb, was a particular act of Almighty Power. The phosphorescence of minerals, buried since the origin of things in the bowels of the earth, coincides strictly with the Mosaic account of the creation. We shall therefore regard light, the first-born element of Chaos, as an independent essence, universally distributed through the mineral, vegetable, and animal world, capable of being disengaged from its latent state by various natural and artificial operations. These are

1. Friction.

To this head, belong electrical light, and that evolved from the attrition of pieces of quartz, even under water.

2. Condensation and expansion. If atmospheric air or oxygen be suddenly compressed in a glass syringe, or if a glass ball, filled with the latter, be suddenly broke *in vacuo*, a flash of light is instantly perceived.

3. Heat. If air which has been heated up to 900° of Fahrenheit, and which is in itself obscure, be made to fall on pieces of metal, earth, &c. it will speedily communicate to them the power of radiating light. The brilliant flame exhibited in the burning of charcoal and phosphorus, is shown in the article COMBUSTION, to be merely the ignition of the solid particles of these bodies. At a certain elevation of temperature, about 800° Fahr. all solid bodies begin to give out light. The same effect is produced *in vacuo* by transmitting voltaic electricity through a metallic wire. To this section, we must also refer the phosphorescence of minerals. This curious phenomenon seems to have been first described by Benvenuto Cellini, in his Treatise on Jewellery, published near the beginning of the 16th century. In the year 1663, Mr. Boyle observed, that diamond, when slightly heated, rubbed, or compressed, emitted a light almost equal to that of the glow-worm.

The most complete account which we have of mineral phosphorescence, is that recently given by Dr. Brewster in the first volume of the Edinburgh Phil. Journal. His method of examination was ingenious and accurate. He never reduced the body to powder, but placed a fragment of it upon a thick mass of hot iron, or, in delicate experiments, introduced it into the bottom of a pistol barrel, heated a little below redness.

The following table presents his results:

Names of the Minerals.	*Colour of the Minerals.*	*Colour and Intensity of the Light.*
Fluor spar,	Pink,	Green,
———	Purple,	Bluish,
———	Bluish-white,	Blue,
Compact fluor,	Yellowish,	Fine green,
Sandy fluor,	White,	White sparks,
Calcareous spar,	Yellow,	Yellow,
———	Transparent,	Yellowish,
Limestone from north of Ireland,	———	Yellowish-red,
Phosphate of lime,	Pink,	Yellow,
Arragonite,	Dirty white,	Reddish-yellow,
Carbonate of barytes,	Whitish,	Pale white,
Harmotome,	Colourless,	Reddish-yellow,
Dipyre,	White,	Specks of light,
Grammatite from Glentilt,	———	Yellow,
——— Cornwall,	———	Bluish,
Topaz, Aberdeenshire,	Blue,	Bluish,
———, Brazilian,	Yellow,	Faint yellowish,
——— New Holland,	White,	Bluish,
Rubellite,	Reddish,	Scarlet,
Sulphate of lime,	Yellowish,	Faint light,

Names of the Minerals.	*Colour of the minerals.*	*Colour and Intensity of the Light.*
Sulphate of barytes,	Yellow,	Pale light,
——— ———	Slate colour,	Pale light,
——— strontites,	Bluish,	A fragment shone pretty bright,
——— lead,	Transparent,	Faint and by fits,
Anhydrite,	Reddish,	Faint light,
Sodalite,	Dark green,	Pretty bright,
Bitter spar,	Yellowish,	Faint white,
Red silver ore,	Red,	Pretty bright, but flitting,
Barystrontianite,	White,	Faint,
Arseniate of lead,	Yellowish,	Bright white,
Sphene,	Yellow,	Bright white,
Tremolite,	Whitish,	Reddish-yellow,
Mica,	Greenish,	Whitish,
—— from Waygatz,	Black,	White specks,
————	Brown,	Pretty bright,
Titanium sand,	Black,	Feeble specks,
Hornstone,	Gray,	Yellowish,
Table spar, Dognatska,	Whitish,	Yellowish,
Lapis lazuli,	Blue,	Faint,
Spodumene,	Greenish,	Faint,
Titanite,	Reddish,	Extremely faint,
Cyanite,	Yellowish-white,	Bluish,
Calamine,	Brown,	Faint,
Augite,	Green,	Pretty bright,
Petalite,	Reddish tinge,	Blue and very bright,
Abestus, rigid,	————	Pretty bright,
Datholite,	Transparent,	Bright,
Corundum,	Brown,	Bright,
Anatase,	Dark,	Reddish-yellow,
Tungstate of lime,	Yellowish-white,	Brilt. like a burning coal,
Quartz,	The phosphorescence of these nine minerals was observed in the pistol barrel.	Very faint,
Amethyst,		Faint,
Obsidian,		Pretty bright; dirty blue,
Mesotype from Auvergne,		Very faint,
Glassy actinolite,		Little specks,
Ruby silver,		Rather bright,
Muriate of silver,		Blue,
Carbonate of copper,		Very faint,
Green telèsie,		Pale blue, & pretty bright.

The phosphorescence of anatase is entirely different from that of the other minerals. It appears suddenly like a flame, and is soon over. Dr. Brewster found, in opposition to what Mr. Wedgwood had stated, that exposure of green fluor spar to the heat of a common fire in a crucible for half an hour, entirely deprived it of phosphorescence. Though he placed one fragment for several days in the beams of a summer sun, and even exposed it to the bright light near the focus of a burning glass, he could not succeed in obtaining from it the slightest indication of phosphorescence. The light emitted in combustion belongs to the same head. The phosphoric light of minerals has the same properties as the direct light of the sun, according to Dr. Brewster.

4. Light emitted from bodies in consequence of the action of extraneous light. To this section we refer solar phosphori. The most powerful of these is the artificial compound of Canton. If we mix three parts of calcined oyster shells in powder, with one of flowers of sulphur, and ramming the mixture into a crucible, ignite it for half an hour, we shall find, that the bright parts will, on exposure to the sunbeam, or to the common day-light, or to an electrical explosion, acquire the faculty of shining in the dark, so as to illuminate the dial of a watch, and make its figures legible. It will, indeed, after a while, cease to shine; but if we keep the powder in a well corked phial, a new exposure to the sunbeam will restore the luminescence Oyster shells, stratified with sulphur, in a crucible, and ignited, yield a more powerful phosphorescent substance than the powder. It also must be kept in a close phial. When the electric discharge is transmitted along the surfaces of certain bodies, or a little above them, a somewhat durable phosphorescence is occasioned, which probably belongs to this division.

Sulphate of baryt.	gives a bright green light,
Carbonate	Do. less brilliant,
Acetate of potash,	Brilliant green light,
Succinic acid,	Do. more durable,
Loaf sugar,	Do.
Selenite,	Do. but transient,
Rock-crystal,	Light red, and then white,
Quartz,	Dull white light,
Borax,	Faint green light,
Boracic acid,	Bright green light.

Mr. Skrimshire has given an extensive catalogue of such substances in Nicholson's Journal, 8vo. vols. 15, 16, and 19. He shows that Canton's pyrophorus yields more light by this treatment than any other body; but that almost every native mineral, except metallic ores and metals, becomes more or less luminous after the electric explosion. A slate from Colly Weston, Northamptonshire, which effervesced with acids, gives a beautiful effect. When the explosion of a jar is taken *above* the centre of a piece some inches square, not only the part above the discharging rods is luminous, but the surface of the plate appears bespangled, with very minute brilliant points to some distance from its centre; and when the points of the dischargers rest upon the surface of the slate, these minute spangles are detached and scattered about the table in a luminous state.

5. Light emitted during chemical changes, independent of heat, or in which no perceptible heat is developed. The substances from which such light is emitted, are principally the following:—

Marine animals, both in a living state and when deprived of life. As instances of the first may be mentioned, the shell-fish called *pholas*, the *medusa phosphorea*, and various other *mollusca*. When deprived of life, marine fishes, in general, seem to abound with this kind of light. The flesh of quadrupeds also evolves light. In the class of insects, are many which emit light very copiously, particularly several species of *fulgora*, or lantern-fly; and of *lampyris* or glow-worm; also the *scolopendra electrica*, and a species of crab called *cancer fulgens*. Rotten wood is well known to evolve light copiously, as well as peat-earth.

Dr. Hulme, in an elaborate dissertation on this light, published in the Phil. Trans for 1790. establishes the following important propositions:—

1. The quantity of light emitted by dead animal substances, is not in proportion to the degree of putrefaction in them, as is commonly supposed; but, on the contrary, the greater the putrescence, the less light is evolved. It would seem, that this element, endowed with pre-eminent elasticity, is the first to escape from the condensed state of combination in which it had been imprisoned by the powers of life; and is followed, after some time, by the relatively less elastic gases, whose evolution constitutes putrefaction.

2. This light is a constituent chemical principle of some bodies, particularly of marine fishes, from which it may be separated by a peculiar process, retained and rendered permanent for some time. A solution of 1 part of sulphate of magnesia, in 8 of water, is the most convenient menstruum for extracting, retaining and increasing the brilliancy of this light. Sulphate and muriate of soda, also answer in a proper state of dilution with water. When any of the saline solutions is too concentrated, the light disappears, but instantly bursts forth again from absolute darkness, by dilution with water. I have frequently made this curious experiment with the light procured from whiting. Common water, lime-water, fermented liquors, acids even very dilute, alkaline leys, and many other bodies, permanently extinguish this spontaneous light. Boiling water destroys it, but congelation merely suspends its exhibition; for it reappears on liquefaction. A gentle heat increases the vividness of the phenomenon, but lessens its duration.

We shall conclude the subject of light with the following important practical fact and practical problem.

1. Count Rumford has shown that the quantity of light emitted by a given portion of inflammable matter in combustion, is proportional in some high ratio to the elevation of temperature; and that a lamp, having many wicks very near each other, so as mutually to increase their heat, burns with infinitely more brilliancy than the Argand's lamps in common use.

2. To measure the proportional intensities of two or more lights. Place them a few inches asunder, and at the distance of a few feet or yards from a screen of white paper, or a white wall. On holding a small card, near the wall, two shadows will be projected on it, the darker one by the interception of the brighter light, and the lighter shadow by the interception of the duller light. Bring the fainter light nearer to the card, or remove the brighter one further from it, till both shadows acquire the same intensity; which the eye can judge of with great precision, particularly from the conterminous shadows at the angles. Measure now the distances of the two lights from the wall or screen, square them, and you have the ratio of illumination. Thus if an Argand flame, and a candle, stand at the distances of 10 feet and 4 feet, respectively, when their shadows are equally deep, we have 10^2 and 4^2, or 100 and 16, or 6¼ and 1, for their relative quantities of light.*

* Lilalite. The mineral Lepidolite.*

* Lime. The oxide of calcium, one of the primitive earths. This subject has been already treated of under *Calcium*. We

shall add here, that in preparing the bleaching powder, calcined magnesian limestone would be an excellent substitute for common lime; and it may be had abundantly from many districts both of England and Ireland. Scotland seems to possess little of it. See DOLOMITE.

The most important applications of lime are to agriculture and building; on which subjects Sir H. Davy has given some excellent observations.

Quicklime in its pure state, whether in powder, or dissolved in water, is injurious to plants. Grass is killed by watering it with lime-water. But lime in its state of combination with carbonic acid, is a useful ingredient in soils. Calcareous earth is found in the ashes of the greater number of plants; and exposed to the air, lime cannot long continue caustic, but soon becomes united to carbonic acid.

When lime, whether freshly burnt or slacked, is mixed with any moist fibrous vegetable matter, there is a strong action between the lime and the vegetable matter, and they form a kind of compost together, of which a part is usually soluble in water. By this kind of operation, lime renders matter, which was before comparatively inert, nutritive; and as charcoal and oxygen abound in all vegetable matters, it becomes at the same time converted into carbonate of lime.

Mild lime, powdered limestone, marls, or chalks, have no action of this kind upon vegetable matter: by their action they prevent the too rapid decomposition of substances already dissolved; but they have no tendency to form soluble matters.

It is obvious from these circumstances, that the operation of quicklime, and marl or chalk, depends upon principles altogether different. Quicklime, in the act of becoming mild, prepares soluble out of insoluble matter.

It is upon this circumstance that the operation of lime in the preparation for wheat crops depends: and its efficacy in fertilizing peats, and in bringing into a state of cultivation all soils abounding in hard roots or dry fibres, or inert vegetable matter.

The solution of the question, whether quicklime ought to be applied to a soil, depends upon the quantity of inert vegetable matter that it contains. The solution of the question, whether marl, mild lime, or powdered limestone, ought to be applied, depends upon the quantity of calcareous matter already in the soil. All soils are improved by mild lime, and ultimately by quicklime, which do not effervesce with acids; and sands more than clays.

When a soil, deficient in calcareous matter, contains much *soluble* vegetable manure, the application of quicklime should always be avoided; as it either tends to decompose the soluble matters by uniting to their carbon and oxygen so as to become mild lime, or it combines with the soluble matters, and forms compounds having less attraction for water than the pure vegetable substance.

The case is the same with respect to most animal manures; but the operation of the lime is different in different cases, and depends upon the nature of the animal matter. Lime forms a kind of insoluble soap with oily matters, and then gradually decomposes them by separating from them oxygen and carbon. It combines likewise with the animal acids, and probably assist their decomposition by abstracting carbonaceous matter from them combined with oxygen; and consequently it must render them less nutritive. It tends to diminish likewise the nutritive powers of albumen from the same causes; and always destroys, to a certain extent, the efficacy of animal manures, either by combining with certain of their elements, or by giving to them new arrangements. Lime should never be applied with animal manures, unless they are too rich, or for the purpose of preventing noxious effluvia. It is injurious when mixed with any common dung, and tends to render the extractive matter insoluble.

In those cases in which fermentation is useful to produce nutriment from vegetable substances, lime is always efficacious, as with tanners' bark.

The subject of the application of the magnesian limestone is one of great interest.

Magnesia has a much weaker attraction for carbonic acid than lime, and will remain in the state of caustic or calcined magnesia for many months, though exposed to the air. And as long as any caustic lime remains, the magnesia cannot be combined with carbonic acid, for lime instantly attracts carbonic acid from magnesia.

When a magnesian limestone is burnt, the magnesia is deprived of carbonic acid much sooner than the lime; and if there is not much vegetable or animal matter in the soil to supply, by its decomposition, carbonic acid, the magnesia will remain for a long while in the caustic state; and in this state acts as a poison to certain vegetables. And that more magnesian lime may be used upon rich soils, seems to be owing to the circumstance, that the decomposition of the manure in them supplies carbonic acid. But magnesia in its mild state, *i. e.* fully combined with carbonic acid, seems to be always a useful constituent of soils.

The Lizard Downs which contain magnesian earth, bear a short and green grass, which feeds sheep producing excellent mutton; and the cultivated parts are amongst the best corn lands in the county of Cornwall.

It is obvious, from what has been said, that lime from the magnesian limestone may be applied in large quantities to peats; and that where lands have been injured by the application of too large a quantity of magnesian lime, peat will be a proper and efficient remedy.

There are two modes in which lime acts as a cement: in its combination with water, and in its combination with carbonic acid.

When quicklime is rapidly made into a paste with water, it soon loses its softness, and the water and the lime form together a solid coherent mass, which consists of 1 part of water to 3 parts of lime. When hydrate of lime, whilst it is consolidating, is mixed with red oxide of iron, alumina, or silica, the mixture becomes harder, and more coherent than when lime alone is used; and it appears that this is owing to a certain degree of chemical attraction between hydrate of lime and these bodies; and they render it less liable to decompose by the action of the carbonic acid in the air, and less soluble in water.

The basis of all cements that are used for works which are to be *covered with water*, must be formed from hydrate of lime; and the lime made from impure limestones answers this purpose very well. Puzzolana is composed principally of silica, alumina, and oxide of iron; and it used mixed with lime to form cements intended to be employed under water. Mr. Smeaton, in the construction of the Eddystone light-house, used a cement composed of equal parts by weight of slacked lime and puzzolana. Puzzolana is a decomposed lava. Tarras, which was formerly imported in considerable quantities from Holland, is a mere decomposed basalt: two parts of slacked lime and one part of tarras form the principal part of the mortar used in the great dykes of Holland. Substances which will answer all the ends of puzzolana and tarras are abundant in the British islands. An excellent red tarras may be procured in any quantities from the Giants' Causeway, in the north of Ireland; and decomposing basalt is abundant in many parts of Scotland, and in the northern districts of England in which coal is found.

Parker's cement, and cements of the same kind made at the alum works of Lord Dundas and Lord Mulgrave, are mixtures of calcined ferruginous, silicious, and aluminous matter, with hydrate of lime.

The cements which act by combining with carbonic acid, or the common mortars, are made by mixing together slacked lime and sand. These mortars, at first solidify as hydrates, and are slowly converted into carbonate of lime by the action of the carbonic acid of the air. Mr. Tennant found that a mortar of this kind, in three years and a quarter, had regained 63 per cent of the quantity of carbonic acid gas, which constitutes the definite proportion in carbonate of lime. The rubbish of mortar from houses owes its power to benefit lands principally to the carbonate of lime it contains, and the sand in it; and its state of cohesion renders it particularly fitted to improve clayey soils.

The hardness of the mortar in very old buildings depends upon the perfect conversion of all its parts into carbonate of lime. The purest limestones are the best adapted for making this kind of mortar; the magnesian limestones make excellent water cements, but act with too little energy upon carbonic acid gas to make good common mortar.

The Romans, according to Pliny, made their best mortar a year before it was used; so that it was partially combined with carbonic acid gas before it was employed.

In burning lime there are some particular precautions required for the different kinds of limestones. In general, one bushel of coal is sufficient to make four or five bushels of lime. The magnesian limestone requires less fuel than the common limestone. In all cases in which a limestone containing much aluminous or siliceous earth is burnt, great care should be taken to prevent the fire from becoming too intense; for such lime easily vitrifies, in consequence of the affinity of lime for silica and alumina And as in some places there are no other limestones than such as contain other earths, it is important to attend to this circumstance. A moderately good lime may be made at a low red heat; but it will melt into a glass at a white heat. In limekilns for burning such lime, there should be always a damper.

In general, when limestones are not magnesian, their purity will be indicated by their loss of weight in burning; the more they lose, the larger is the quantity of calcareous matter they contain. The magnesian limestones contain more carbonic acid than the common limestones; and all of them lose more than half their weight by calcination.

The most important compounds of lime, are treated of under the different acids and combustibles.*

* Limestone. A genus of minerals, which Professor Jameson divides into the four following species: 1. Rhomb-spar; 2. Dolomite; 3. Limestone; and, 4. Arragonite. We shall consider the third species here. The same excellent mineralogist divides limestone into twelve sub-species.

1. Foliated limestone; of which there are two kinds, calcareous spar, and foliated granular limestone. The first will be found in its alphabetical place in the Dictionary.

Granular foliated limestone. Colour white, of various shades; sometimes it is spotted. Massive, and in distinct angulo-granular concretions. Lustre glistening, between pearly and vitreous. Fracture foliated. Translucent. Hard as calcareous spar. Brittle. Sp. gr. Carrara marble 2.717. It generally phosphoresces when pounded, or when thrown on glowing coals. Infusible. Effervesces with acids. It is a pure carbonate of lime. It occurs in beds in granite, gneiss, &c. and rarely in secondary rocks. It is found in all the great ranges of primitive rocks in Europe. Parian marble, Pentelic marble, the Marmo Grecô, the white marble of Luni, of Carrara, and of Mount Hymettus, the translucent white marble of statuaries, and flexible white marble, are the chief of the white marbles which the ancients used for sculpture and architecture. The red antique marble, Rosso antico of the Italians, and Egyptian of the ancients; the Verde antico, an indeterminate mixture of white marble and green serpentine; yellow antique marble; the antique Cipolin marble, marked with green-coloured zones, caused by talc or chlorite; and African breccia marble, are the principal coloured marbles of the ancients. The Scottish marbles are, the red and white Tiree, the former of which contains hornblende, sahlite, mica, and green earth; the Iona marble, harder than most others, consisting of limestone and tremolite, or occasionally a dolomite; the Skye marble; the Assynt in Sutherland, introduced into commerce by Mr. Joplin of Gateshead. It is white and gray, of various shades. The Glentilt marble; the Balachulish; the Boyne; the Blairgowrie; and the Glenavon. Hitherto but few marbles of granular foliated limestone have been quarried in England. The *Mona marble* is not unlike *Verde antico*. The black marbles of Ireland, now so generally used by architects, are Lucullites. The Toreen, in the county of Waterford, is a fine variegated sort; and a gray marble beautifully clouded with white, has been found near Kilcrump, in the same county. At Loughlougher in Tipperary, a fine purple marble is found. The county of Kerry affords several variegated marbles. Of the continental marbles a good account is given by Professor Jameson, *Mineralogy*, vol. ii. p. 502.

2d Sub-species. Compact limestone; of which there are three kinds, common compact limestone, blue Vesuvian limestone, and roestone.

Common compact limestone has usually a gray colour, with coloured delineations. Massive, corroded, and in various extraneous shapes. Dull. Fracture fine splintery. Translucent on the edges. Softer than the preceding sub-species. Easily frangible. Streak grayish-white. Sp. gr. 2.6 to 2.7. It effervesces with acids, and burns into quicklime. It is a carbonate of lime, with variable and generally minute proportions of silica, alumina, iron, magnesia, and manganese. It occurs principally in secondary formations, along with sandstone, gypsum, and coal. Many animal petrifactions, and some vegetable, are found in it. It is rich in ores of lead and zinc; the English mines of the former metal being situated in limestone. When it is so hard as to take a polish, it is worked as a marble, under the name of shell, or *lumacella* marble. It abounds in the sandstone and coal formations, both in Scotland and England; and in Ireland it is a very abundant mineral in all the districts, where clay-slate and red-sandstone occur. The Florentine marble, or *ruin marble*, is a compact limestone. Seen at a distance, slabs of this stone resemble drawings done in bistre.

2. Blue Vesuvian limestone. Colour dark bluish-gray, partly veined with white. Rolled and uneven on the surface. Fracture fine earthy. Opaque. Streak white. Semi-hard in a low degree. Feels heavy. Its constituents are, lime 58, carbonic acid 28.5, water somewhat ammoniacal 11, magnesia 0.5, oxide of iron 0.25, carbon 0.25, and silica 1.25.—*Klaproth*. It is found in loose masses among unaltered ejected minerals, in the neighbourhood of Vesuvius. In mosaic work, it is used for representing the sky.

3. Roestone. Colours brown and gray. Massive, and in distinct concretions, which are round granular. Dull. Opaque. Fracture of the mass round granular. Approaching to soft. Brittle. Sp. gr. 2.6 to 2.68. It dissolves with effervescence in acids. It occurs along with red-sandstone and *lias* limestone. In England this rock is called Bath-stone, Ketton-stone, Portland-stone, and Oolite. It extends, with but little interruption, from Somersetshire to the banks of the Humber in Lincolnshire. It is used in architecture, but it is porous, and apt to moulder away, as is seen in the ornamental work of the Chapel of Henry VIII.

3d Sub-species. Chalk, which see.

4th. Agaric mineral, or rock-milk. Colour white. In crusts or tuberose pieces. Dull. Composed of fine dusty particles. Soils strongly. Feels meagre. Adheres slightly to the tongue. Light, almost supernatant. It dissolves in muriatic acid with effervescence, being a pure carbonate of lime. It is found on the north side of Oxford, between the Isis and the Cherwell, and near Chipping Norton; as also in the fissures of limestone caves on the Continent. It is formed by the attriction of water on limestone rocks.

5th Sub-species. Fibrous limestone; of which there are two kinds, satin-spar, or the common fibrous; and fibrous calc-sinter. *Satin-spar*. White of various shades. Massive, and in distinct fibrous concretions. Lustre glistening and pearly; fragments splintery; feebly translucent; as hard as calcareous spar; easily frangible; sp. gr. 2.7. Its constituents are, lime 50.8, carbonic acid 47.6? Stromeyer says it contains some per cents of gypsum. It occurs in thin layers in clay-slate at Aldstone-moor in Cumberland; in layers and veins in the middle district of Scotland, as in Fifeshire. It is sometimes cut into necklaces, &c.

Fibrous calc-sinter It is used as marble, and the ancients formed it into unguent-vases, the *alabaster-box* of Scripture. See Calc-sinter.

6th Sub-species. Tufaceous limestone, or Calc-tuff. Colour gray. Massive, and in imitative shapes, enclosing leaves, bones, shells, &c. Dull. Fracture fine grained uneven. Opaque. Soft. Feels rough. Brittle. It is pure carbonate of lime. It occurs in beds, generally in the neighbourhood of rivers; near Starly-burn in Fifeshire, and other places. Used for lime.

7th Sub-species. Pisiform limestone, or Peastone. Colour yellowish-white. Massive, and in distinct concretions, which are round granular, composed of others which are very thin and concentric lamellar. In the centre there is a bubble of air, a grain of sand, or of some mineral matter. Dull. Fracture even. Opaque. Soft. Brittle. Sp. gr. 2.532. It is carbonate of lime. It is found in great masses in the vicinity of Carlsbad in Bohemia.

8th Sub-species. Slate-spar. Schieferspath. Colour white, of various shades. Massive, and in distinct curved lamellar concretions. Lustre glistening and pearly. Feebly translucent. Soft; between sectile and brittle. Feels rather greasy. Sp. gr. 2.63. Its constituents are carbonate of lime, with three per cent of oxide of manganese. It occurs in primitive limestone, in metalliferous beds and in veins. It is found in Glentilt; in Assynt; in Cornwall; and near Granard in Ireland.

9th Sub-species. Aphrite, which see.

10th Sub-species. Lucullite; of which there are three kinds, compact, prismatic, and foliated.

§ 1. Compact is subdivided into the common or black marble; and the stinkstone.

a. The common compact. Colour grayish-black. Massive. Glimmering. Fracture fine grained uneven. Opaque. Semi-hard. Streak, dark ash-gray. Brittle. Sp. gr. 3. When two pieces are rubbed together, a fetid urinous odour is exhaled, which is increased by breathing on them. It burns white, but forms a black-coloured mass with sulphuric acid. Its constituents are, lime 53.38, carbonic acid 41.5, carbon 0.75, magnesia and oxide of manganese 0.12, oxide of iron 0.25, silica 1.13, sulphur 0.25, muriates and sulphates of potash with water 2.62.—*John.* It is said to occur in beds in primitive and older secondary rocks. Hills of this mineral occur in the district of Assynt in Sutherland. Varieties of it are met with in Derbyshire; at Killenny; in the counties of Cork and Galway. The consul Lucullus admired it so much, as to give it his name, It is the *Nero antico* of the Italians.

b. Stinkstone, or *Swinestone.* Colour white, of many shades, cream-yellow, gray, black, and brown, Massive, disseminated, and in distinct granular concretions. Dull. Fracture splintery. Opaque. Semi-hard. Streak grayish-white. Emits a fetid odour on friction. Brittle. Sp. gr. 2.7. The same chemical characters as the preceding. Its constituents are, 88 carbonate of lime, 4.13 silica, 3.1 alumina. 1.47 oxide of iron, 0.58 oxide of manganese, 0.30 carbon, 0.58 lime; sulphur, alkali, salt, water, 2.20.—*John.* It occurs in beds in secondary limestone, alternating occasionally with secondary gypsum and beds of clay. It is found in the vicinity of North Berwick, resting on red sandstone, and in the parish of Kirbean in Galloway. It is employed for burning into lime.

§ 2. Prismatic lucullite. Colours black, gray, and brown. Massive, in balls, and in distinct concretions. External surface sometimes streaked. Internal lustre shining. Cleavage threefold. Translucent on the edges. Semi-hard. Streak gray-coloured. Brittle. When rubbed it emits a strongly fetid urinous smell. Sp. gr. 2.67. When its powder is boiled in water, it gives out a transient hepatic odour. The water becomes slightly alkaline. It dissolves with effervescence in muriatic acid, leaving a charcoaly residuum. Its constituents resemble those of the preceding. It occurs in balls, in brown dolomite, at Building-hill, near Sunderland. It was at one time called *madreporite.*

§ 3. Foliated or sparry lucullite. Colours white, gray, and black. Massive, disseminated and crystallized in acute six-sided pyramids. Internal lustre glimmering. Fragments rhomboidal. Translucent. Semi-hard. Brittle. Emits on friction a urinous smell. Sp. gr. 2.65. In other respects similar to the preceding. It is found in veins at Andreasberg, in the Hartz.

11th Sub-species. Marl; of which there are two kinds, earthy and compact. *Earthy marl* has a gray colour, consists of fine dusty particles, feebly cohering; dull; soils slightly; is light; effervesces with acids; and emits a urinous smell when first dug up. Its constituents are carbonate of lime, with a little alumina, silica, and bitumen. It occurs in beds in the secondary limestone and gypsum formations in Thuringia and Mansfeld. *Compact marl* has a gray colour; is massive, vesicular, or in flattened balls; contains petrifactions; dull; fracture earthy, but in the great slaty; yields to the nail; opaque; streak grayish-white; brittle; feels meagre; sp. gr. 2.4. It intumesces before the blow-pipe, and melts into a greenish-black slag. It effervesces with acids. Its constituents are carbonate of lime 50, silica 12, alumina 32, iron and oxide of manganese 2.—*Kirwan.* It occurs in beds in the secondary floetz limestone. It is frequent in the coal formations of Scotland and England.

12th Sub-species. Bituminous marl-slate. Colour grayish-black. Massive, and frequently with impressions of fishes and plants. Lustre glistening. Fracture slaty. Opaque. Shining streak. Soft. Sectile. Frangible. Sp. gr. 2.66. It is said to be carbonate of lime, with albumen, iron, and bitumen. It occurs in floetz limestone. It frequently contains cupreous minerals, petrified fishes, and fossil remains of cryptogamous plants. It abounds in the Hartzgebirge.—*Jameson.**

Liquefaction. A chemical term, in some instances synonymous with the word *fusion*, in others with the word *deliquescence*, and in others again with the word *solution*.

* **Liquidity.** See Caloric.*

Liquor of Flints. See Silica.

* **Lithia.** A new alkali. It was discovered by M. Arfwedson, a young chemist of great merit, employed in the laboratory of M. Berzelius. It was found in a mineral from the mine of Uten, in Sweden, called *petalite*, by M. d'Andrada, who first distinguished it. Sir H. Davy demonstrated by voltaic electricity, that the basis of this alkali is a metal, to which the name of *lithium* has been given.

Berzelius gives the following simple process as a test for lithia in minerals:—

A fragment of the mineral, the size of a pin's head, is to be heated with a small excess of soda, on a piece of platinum foil, by a blow-pipe for a couple of minutes. The stone is decomposed, the soda liberates the lithia, and the excess of alkali preserving the whole fluid at this temperature, it spreads over the foil, and surrounds the decomposed mineral. That part of the platinum near to the fused alkali becomes of a dark colour, which is more intense, and spreads over a larger surface, in proportion as there is more lithia in the mineral. The oxidation of the platinum does not take place beneath the alkali, but only around it, where the metal is in contact with both air and lithia. Potash destroys the reaction of the platinum on the lithia, if the lithia be not redundant. The platinum resumes its metallic surface, after having been washed and heated.

Lithia may be obtained by fusing petalite with potash, dissolving the whole in muriatic acid, evaporating to dryness, and digesting in alcohol. The muriate of lithia, being very soluble in that fluid, is taken up, while the other salts remain. By a second evaporation and solution in alcohol, it is obtained perfectly pure. The muriate is itself a salt very characteristic of the alkali. It may easily be decomposed by carbonate of silver; and the carbonate thus procured, when treated with lime, yields pure lithia. Dr. Gmelin fused petalite with five times its weight of nitrate of barytes, at a white heat, in a platinum crucible; digested the mass in muriatic acid; evaporated the solution to dryness; dissolved in water; separated the silica; and added rather more sulphuric acid than was equivalent to the barytes. The sulphate of barytes was got rid of by solution in water and filtration. The liquid was now concentrated by evaporation to expel the excess of muriatic acid. It was then supersaturated with carbonate of ammonia, which threw down the alumina and the oxide of iron. The filtered liquid was evaporated to dryness, and the residue was ignited, to drive off the ammoniacal sulphate and muriate. The remainder was dissolved in water, and hydrosulphuret of ammonia was added to the solution to separate the manganese. Being now filtered, evaporated, and ignited, it was pure sulphate of lithia, from which he obtained the carbonate by adding acetate of barytes, and decomposing the resulting acetate of lithia by a red heat.

The first is the process of M. Vauquelin, and is vastly the simpler of the two. The most complete account, however, which we have of lithia and its compounds, is that of Dr. Gmelin. He had the benefit indeed of M. Vauquelin's very able researches, published in the *Ann. de Chimie et Phys.* vii. 287. Dr. Gmelin's memoir is inserted in the 62d volume of *Gilbert's Annalen.*

Caustic lithia has a very sharp burning taste. It destroys the cuticle of the tongue, like potash. It does not dissolve with great facility in water, and appears not to be much more soluble in hot than in cold water. In this respect it has an analogy with lime. Heat is evolved during its solution in water.

When exposed to the air, it does not attract moisture, but absorbs carbonic acid, and becomes opaque. When exposed for an hour to a white heat in a covered platinum crucible, its bulk does not appear to be diminished; but it has absorbed a quantity of carbonic acid.

It dissolves only in small quantity in alcohol of the specific gravity 0.85. When weak alcohol is added to an aqueous solution of lithia in a well stopped phial, no change takes place at first; but after some hours the lithia precipitates in the state of a white powder.

Lithia unites with sulphur, according to Vauquelin. Sulphuret of lithia has a yellow colour, dissolves readily in water, and is decomposed by acids in the same way as the other alkaline sulphurets.

Phosphorus decomposes water with the help of caustic lithia. If we heat in a retort phosphorus with a solution of caustic lithia in water, phosphuretted hydrogen gas is disengaged, which catches fire when it comes into the air.

Neutral sulphate of lithia forms small prismatic crystals, having a good deal of lustre, sometimes constituting pretty long, but narrow tables. When exposed to the air, they undergo only an insignificant efflorescence. This salt has a saline and scarcely bitter taste. It dissolves pretty readily in water, and melts when exposed to a temperature scarcely reaching a red heat.

Bisulphate of lithia dissolves in water with greater facility than the neutral salt. It forms six-sided tables, in which two of the faces, which are parallel to each other, far exceed the remaining ones in length. When exposed to a very high temperature, it gives out sulphurous acid and oxygen gas, and is converted into the neutral sulphate.

According to Arfwedson, this bisalt dissolves with more difficulty in water than the neutral salt.

Phosphate of lithia.—Phosphoric acid, when dropped into the solution of sulphate of lithia, occasions no precipitate. But when the uncombined acid is saturated by ammonia, the phosphate of lithia is precipitated in the state of white flocks, which are insoluble in water.

When a drop of phosphoric acid is let fall into a very dilute solution of carbonate of lithia, no precipitate falls; but when the liquid is heated, the carbonic acid gas is disengaged, and phosphate of lithia falls down. From this it would seem, that the solubility of phosphate of lithia in water is owing to the presence of the carbonic acid.

There exists likewise a *biphosphate of lithia*. It is obtained by dissolving the neutral salt in phosphoric acid. By a very slow evaporation of this solution, we obtain transparent granular crystals.

Nitrate of lithia forms four-sided prisms with rhomboidal bases. It has a very pungent taste, and seems to surpass almost all other salts in deliquescency. In a very hot day, it crystallized in the sun; but deliquesced again in the shade. It dissolves in the strongest alcohol.

Carbonate of lithia constitutes a white powder. It dissolves with great difficulty in cold water. According to Vauquelin, 100 parts of water dissolve scarcely one part of this salt. It is more soluble in hot water. A solution of carbonate of lithia containing only 1-1000th of its weight of the salt, acts strongly as an alkali.

0.535 grammes of fused carbonate of lithia were, by means of sulphuric acid and exposure to a strong heat, converted into 0.765 of neutral sulphate of lithia. Now this quantity of sulphate contains 0.2436 of lithia.

Hence 0.535 of carbonate of lithia are composed of

Lithia,	0.2436
Carbonic acid,	0.2914
	0.5350

Or in the 100 parts,

Lithia,	45.54
Carbonic acid,	54.46
	100.00

But the oxygen in

45.54 lithia is = 19.09
54.46 carbonic acid = 39.59

and 2 × 19.09 = 38.18, a number differing but little from 39.59.

The solution of carbonate of lithia is decomposed by lime and barytes-water. It is insoluble in alcohol.

The platinum crucible in which carbonate of lithia has been exposed to a red heat, gives obvious indications of having been attacked, its surface assuming a dark olive-green colour; but the metallic lustre is again restored by rubbing the crucible with coarse sand and water.

Muriate of lithia forms small regular cubes very similar to common salt in their taste. The easiest method of obtaining the crystals, is to expose the solution to the sun in a hot day. The crystals deliquesce very speedily when exposed to the air, but not with so much rapidity as nitrate of lithia. This salt does not melt when exposed to the red heat produced by the action of a spirit lamp; but when exposed in a platinum crucible, not completely covered, to an incipient white heat, it is fused into the chloride.

Chromate of lithia forms orange-yellow crystals, which appear to contain an excess of acid. They are oblique parallelopipeds with rhomboidal bases. Sometimes they exhibit a dendritical vegetation. This salt is soluble in water.

Oxalate of lithia.—A portion of carbonate of lithia was saturated with oxalic acid. The neutral salt crystallizes with difficulty. The crystals have the appearance of small opaque protuberances, and dissolve with facility in water. To the neutral solution of oxalate of lithia was added a quantity of oxalic acid, exactly equal to that already combined with the lithia. By evaporation, small transparent granular crystals of *binoxalate of lithia* were obtained. They appeared to dissolve with facility in water, though not to be so soluble as the neutral salt.

Neutral *tartrate of lithia* dissolves with facility in water, but does not crystallize, forming a white opaque mass, which does not deliquesce when exposed to the air. When tartaric acid is added to the solution of the neutral tartrate, no crystallizable bitartrate is formed; but perhaps we may deduce the existence of such a salt from the fact, that when the solution is evaporated, no crystals of tartaric acid make their appearance.

When the solution is evaporated to dryness, we obtain a white opaque mass, which exhibits no appearance of crystallization, and which dissolves with facility in water.

Acetate of lithia, when evaporated, forms a sirupy mass, which cracks on cooling; so that the glass looks as if it had burst. This matter deliquesces in the air, and sometimes, while attracting moisture, crystalline plates appear in it.

* *Tartrate of lithia and potash.*—If the excess of acid of bitartrate of potash be saturated by means of carbonate of lithia, we obtain, by spontaneous evaporation, a salt which forms large crystals, having the shape of four-sided prisms terminated by parallelograms, with angles very nearly right. The diagonals of these terminal faces are distinctly marked, and the four triangles formed by means of them are streaked parallel to the edges of these faces. This salt dissolves readily in water, and has a saline and scarcely bitter taste. When exposed to the air, it effloresces slightly, and only on the surface.

Tartrate of lithia and soda.—Bitartrate of soda was neutralized by means of carbonate of lithia. By spontaneous evaporation, the liquid deposited long rectangular four-sided prisms, frequently terminated by an oblique face. This salt dissolves with facility in water, and effloresces only slightly, and on the surface. Its taste is purely saline, and not strong.

Muriate of platinum does not form a double salt with muriate of lithia. Potash and lithia, therefore, may be very well distinguished from each other by means of muriate of platinum.

From the preceding account of the salts of lithia, we see that they have many properties in common with the salts of soda. Like them, they are neither precipitated by muriate of platinum, nor by tartaric acid. They may, however, be distinguished from the salts of soda by the following properties: When their concentrated solutions are mixed with a concentrated solution of carbonate of soda, a precipitate falls. They are likewise precipitated by phosphate of soda and phosphate of ammonia, when no uncombined acid is present.

In reference to analytical chemistry, it may be remarked, that lithia, potash, and soda, if they should exist in the same compound, may be separated in the following way:—

Lithia may be precipitated by means of phosphoric acid and an excess of caustic ammonia. The phosphate of lithia may be dissolved in acetic acid, and the phosphoric acid precipitated by means of acetate of lead, &c.

When lithia exists in a compound with potash, this last alkali may be precipitated by means of muriate of platinum.

From the results of the preceding experiments, we see, says Dr. Gmelin, that if 10 be the equivalent number for oxygen, the equivalent number for lithium is 13.83, and for lithia 23.83; that for carbonate of lithia by calculation 51.32; but, according to the preceding experiment, 52.32, &c.

Placed in the voltaic circuit, Sir H. Davy showed, that it was decomposed with the same phenomena as the other alkalis. A portion of its carbonate being fused in a platinum capsule, the platinum was rendered positive, and a negative wire brought to the upper surface. The alkali decomposed with bright scintillations, and the reduced metal being separated, afterwards burned. The particles were very similar to sodium. A globule of quicksilver made negative, and brought into contact with the alkaline salt, soon became an amalgam of lithium, and had gained the power of acting on water, with the evolution of hydrogen, and formation of alkali.

M. Vauquelin concludes from his experiments, that 100 parts of lithia contain 43.5 of oxygen, and 56.5 of metallic base; a quantity which, he observes, is greater than that of all the other alkalis. The Editors of the Ann. de Chimie remark, that according to this estimate, the equivalent number of the metal is 12.97, of its oxide 22.97, of its dry sulphate 72.97, and of its crystallized sulphate 82.97. These numbers are adapted to the oxygen *radix* of 10. Dr. Gmelin's analysis of lithia, makes its composition to be, by his own reduction,

Lithium,	58.05
Oxygen,	41.95
	100.00

His neutral sulphate consists of

	Crystallized.	Dry.	
Sulphuric acid,	58.34	68.15	5.000
Lithia,	27.25	31.85	2.3367
Water,	14.41		

The prime equivalent of lithia inferred from this analysis, approaches much nearer to M. Vauquelin's number, than that deduced by Dr. Gmelin himself. If we convert this prime *ratio* into *per cent* proportions, we shall have lithia a compound,

Of Lithium,	57.205	1.3367
Oxygen,	42.795	1.0000

From his analysis of the carbonate, the prime equivalent of lithia comes out, as nearly as possible, 2.3. We are therefore warranted to consider 1.3 as the prime of lithium, from the concurring experiments, both of M. Vauquelin and Dr. Gmelin. I cannot see how the Doctor's own ingenious and accurate experiments on these two salts, permitted him to make so erroneous an estimate of the equivalent of lithia, as 23.83, instead of 23⅓ or 23.*

LITHIC ACID. See ACID (LITHIC).

*LITHOMARGE. Stone-marrow, a mineral of which there are two kinds, the friable, and the indurated.

Friable Lithomarge. Colour white, massive, and sometimes in crusts. Particles scaly, and feebly glimmering. Streak shining. Slightly cohering. Soils slightly. Feels rather greasy. Adheres to the tongue. Light. Phosphoresces in the dark. Its constituents are, silica 32, alumina 26.5, iron

21, muriate of soda 1.5, and water 17.0—*Klaproth.* It occurs commonly in tin-stone veins.

Indurated Lithomarge. Colours, yellowish and reddish-white. Massive, and amygdaloidal. Dull. Fracture, fine earthy. Opaque. Streak shining. Soft, sectile, and easily frangible. Adheres strongly to the tongue. Feels fine, and greasy. Sp. grav. 2.44. Infusible before the blow-pipe; some varieties phosphoresce, and others, when moistened, afford an agreeable smell like that of nuts. Its constituents are, silica 45.25, alumina 36.5, oxide of iron 2.75. water 14, and a trace of potash.—*Klaproth.* It occurs in veins in prophyry, gneiss, &c. at Rochlitz in Saxony, and at Zöblitz.—*Jameson.**

Litmus. See **Archil.**

Liver of Sulphur. See **Sulphur.**

Lixiviation. The application of water to the fixed residues of bodies, for the purpose of extracting the saline part.

Lixivium. A solution obtained by lixiviation.

Loadstone. See **Ores of Iron.**

* **Loam.** See **Clay.***

Logwood. The tree which yields it is called by Linnæus, Hæmatoxylum campechianum.

Logwood is so heavy as to sink in water, hard, compact, of a fine grain, capable of being polished, and scarcely susceptible of decay. Its predominant colour is red, tinged with orange, yellow, and black.

It yields its colour, both to spirituous and watery menstrua. Alcohol extracts it more readily and copiously than water. The colour of its dyes is a fine red, inclining a little to violet or purple, which is principally observable in its watery decoction. This, left to itself, becomes in time yellowish, and at length black. Acids turn it yellow; alkalis deepen its colour, and give it a purple or violet hue.

Stuffs would take only a slight and fading colour from decoction of logwood, if they were not previously prepared with alum and tartar. A little alum is added also to the bath. By these means they acquire a pretty good violet.

A blue colour may be obtained from logwood, by mixing verdigris with the bath, and dipping the cloth till it has acquired the proper shade.

The great consumption of logwood is for blacks, to which it gives a lustre and velvety cast, and for grays of certain shades. It is also of very extensive use for different compound colours, which it would be difficult to obtain of equal beauty and variety, by means of drugs affording a more permanent dye.

Juice of logwood is frequently mixed with that of brasil, to render colours deeper; their proportion being varied according to the shade desired.

Logwood is used for dyeing silk, violet. For this, the silk must be scoured, alumed, and washed; because, without aluming, it would take only a reddish tinge, that would not stand wetting. To dye silk thus, it must be turned in a cold decoction of logwood, till it has acquired the proper colour: if the decoction were used hot, the colour would be in stripes and uneven.

Bergmann has already observed, that a fine violet might be produced from logwood, by impregnating the silk with solution of tin. In fact, we may thus obtain, particularly by mixing logwood and brasil in various proportions, a great number of fine shades, more or less inclined to red, from lilac to violet. See **Hematin.**

* **Lomonite,** or **Laumonite.** Di-prismatic **Zeolite.***

* **Lucullite.** See **Limestone,** 10th species.*

Lumachella. See **Limestone.**

Luna Cornea. Muriate of silver. See **Silver.**

Lunar Caustic. Nitrate of silver, fused in a low heat. See **Silver.**

Lute. The lutes with which the joinings of vessels are closed, are of different kinds, according to the nature of the operations to be made, and of the substances to be distilled in these vessels.

When vapours of watery liquors, and such as are not corrosive, are to be contained, it is sufficient to surround the joining of the receiver to the nose of the alembic, or of the retort, with slips of paper or of linen, covered with flour-paste. In such cases also slips of wet bladder are very conveniently used.

When more penetrating and dissolving vapours are to be contained, a lute is to be employed of quicklime slacked in the air, and beaten into a liquid paste with whites of eggs. This paste is to be spread upon linen slips, which are to be applied exactly to the joining of the vessels. This lute is very convenient, easily dries, becomes solid, and sufficiently firm. Of this lute, vessels may be formed hard enough to bear polishing on the wheel.

Lastly, when acid and corrosive vapours are to be contained, we must then have recourse to the lute called *fat lute.* This lute is made by forming into a paste some dried clay finely powdered, sifted through a silken searce, and moistened with water, and then by beating this paste well in a mortar with boiled linseed oil, that is, oil which has been rendered drying by litharge dissolved in it, and fit for the use of painters. This lute easily takes and retains the form given to it. It is generally rolled into cylinders of a convenient size. These are to be applied, by flattening them, to the joinings of the vessels, which ought to be perfectly dry, because the least moisture would prevent the lute from adhering. When the joinings are well closed with this fat lute, the whole is to be covered with slips of linen spread with lute of lime and whites of eggs. These slips are to be fastened with packthread. The second lute is necessary to keep on the fat lute, because this latter remains soft, and does not become solid enough to stick on alone.

Fine porcelain clay, mixed with a solution of borax, is well adapted to iron vessels, the part received into an aperture being smeared with it.

Lycopodium. The fine dust of lycopodium, or clubmoss, is properly the seeds of the plant, and when diffused or strewed in the air, it takes fire from a candle, and burns off like a flash of lightning. It is used in the London theatres.

* **Lydian Stone.** Flinty slate.*

* **Lythrodes.** See Scapolite.*

M

Maceration. The steeping of a body in a cold liquor.

Madder, a substance very extensively employed in dyeing, is the root of the rubia tinctorum.

Although madder will grow both in a stiff clayey soil, and in sand, it succeeds better in a moderately rich, soft, and somewhat sandy soil: it is cultivated in many of the provinces of France, in Alsace, Normandy, and Provence: the best of European growth is that which comes from Zealand.

The best roots are about the thickness of a goose quill, or at most of the little finger; they are semi-transparent, and of a reddish colour; they have a strong smell, and the bark is smooth.

Hellot ascribes the superiority of the madder which comes from the Levant to the circumstance of its having been dried in the open air.

The red colouring matter of madder may be dissolved in alcohol, and on evaporation, a residuum of a deep red is left. Fixed alkali forms in this solution a violet, the sulphuric acid a fawn-coloured, and the sulphate of potash a fine red precipitate. Precipitates of various shades may be obtained by alum, nitre, chalk, sugar of lead, and the muriate of tin.

The quantity of aqueous chlorine required to destroy the colour of a decoction of madder, is double what is necessary to destroy that of a decoction of an equal weight of brazil wood.

Wool would receive from madder only a perishable dye, if the colouring particles were not fixed by a base, which occasions them to combine with the stuff more intimately, and which in some measure defends them from the destructive influence of the air. For this purpose, the woollen stuffs are first boiled for two or three hours with alum and tartar, after which they are left to drain; they are then slightly wrung and put into a linen bag, and carried into a cool place, where they are suffered to remain for some days.

The quantities of alum and tartar, as well as their proportions, vary much in different manufactories. Hellot recommends five ounces of alum and one ounce of tartar to each pound of wool. If the proportion of tartar be increased to a certain degree, instead of a red, a deep and durable cinnamon colour is produced; because, as we have seen, acids have a tendency to give a yellow tinge to the colouring particles of madder. Berthollet found, that, by employing one-half tartar, the colour sensibly bordered more on the cinnamon than when the proportion was only one-fourth of the alum.

In dyeing with madder, the bath must not be permitted to boil, because that degree of heat would dissolve the fawn-coloured particles, which are less soluble than the red, and the colour would be different from that which we wish to obtain.

The quantity of madder which Mr. Poerner employs is only one-third of the weight of the wool, and Schaeffer advises only one-fourth.

If wool be boiled for two hours with one-fourth of sulphate of iron, then washed, and afterward put into cold water with one-fourth of madder, and then boiled for an hour, a coffee colour is produced. Bergmann adds, that, if the wool have not been soaked, and if it be dyed with one part of sulphate of iron and two of madder, the brown obtained borders upon a red.

Berthollet employed a solution of tin in various ways, both in the preparation and in the maddering of cloth. He used different solutions of tin, and found that the tint was always more yellow or fawn-coloured, though sometimes brighter than that obtained by the common process.

Mr. Guhliche describes a process for dyeing silk with madder: for one pound of silk he orders a bath of four ounces of alum, and one ounce of a solution of tin; the liquor is to be left to settle, when it is to be decanted, and the silk carefully soaked in it, and left for twelve hours; and after this preparation, it is to be immersed in a bath containing half a pound of madder softened by boiling with an infusion of galls in white wine; this bath is to be kept moderately hot for an hour, after which it is to be made to boil for two minutes. When taken from the bath, the silk is to be washed in a stream of water, and dried in the sun. Mr. Guhliche compares the colour thus obtained, which is very permanent, to the Turkey-red. If the galls be left out, the colour is clearer. A great degree of brightness may be communicated to the first of these, by afterward passing it through a bath of brazil wood, to which one ounce of solution of tin has been added: the colour thus obtained, he says, is very beautiful and durable.

The madder red of cotton is distinguished into two kinds: one is called simple madder red; the other, which is much brighter, is called Turkey or Adrianople red, because it comes from the Levant, and has seldom been equalled in brightness or durability by our artists.

Galls or sumach dispose thread and cotton to receive the madder colour, and the proper mordant is acetate of alumina.

The nitrate and muriate of iron as a mordant, produces a better effect than the sulphate and acetate of the same metal; they afford a beautiful, well saturated violet colour.

The Adrianople red possesses a degree of brightness, which it is difficult for us to approach by any of the processes hitherto mentioned,

Some years ago, Mr. Papillon set up a dyehouse for this red at Glasgow; and in 1790 the commissioners for manufactures in Scotland paid him a premium, for communicating his process to the late Prof. Black, on condition of its not being divulged for a certain term of years. The time being expired, it has been made public, and is as follows:—

Step. I.—For 100 lbs. of cotton, you must have 100 lb. of Alicant barilla, 20 lb. of pearl ashes, 100 lb. of quicklime.

The barilla is to be mixed with soft water in a deep tub, which has a small hole near the bottom of it, stopped at first with a peg. This hole is to be covered in the inside with a cloth supported by two bricks, that the ashes may be prevented from running out at it, or stopping it up, while the ley filters through it. Under this tub must be another, to receive the ley, and pure water is to be passed repeatedly through the first tub, to form leys of different strength, which are kept separate until their strength is examined. The strongest required for use must float an egg, and is called the ley of six degrees of the French hydrometer. The weaker are afterwards brought to this strength by passing them through fresh barilla; but a certain quantity of the weak, which is of two degrees of the above hydrometer, is reserved for dissolving the oil, the gum, and the salt, which are used in subsequent parts of the process. This ley of two degrees is called the weak barilla liquor; the other the strong.

Dissolve the pearl ashes in ten pails, of four gallons each, of soft water, and the lime in fourteen pails.

Let all the liquors stand till they become quite clear, and then mix ten pails of each.

Boil the cotton in this mixture five hours, then wash it in running water, and dry it.

Step. II. Bain bis, or Gray steep.—Take a sufficient quantity (ten pails) of the strong barilla water in a tub, and mix with it two pailfuls of sheep's dung; then pour into it two quart bottles of sulphuric acid, one pound of gum-arabic, and one pound of sal ammoniac, both previously dissolved in a sufficient quantity of weak barilla water; and, lastly, twenty-five pounds of olive oil, previously dissolved, or well mixed with two pails of the weak barilla water.

The materials of this steep being well mixed, tread down the cotton into it until it is well soaked; let it steep twenty-four hours, then wring it hard and dry it.

Steep it again twenty-four hours, and again wring and dry it.

Steep it a third time twenty-four hours, after which wring and dry it; and, lastly, wash it well and dry it.

Step. III. The white steep.—This part of the process is precisely the same with the last in every particular, except that the sheep's dung is omitted in the composition of the steep.

Step. IV. Gall steep.—Boil twenty-five pounds of bruised galls in ten pails of river water, until four or five are boiled away; strain the liquor into a tub, and pour cold water on the galls in the strainer to wash out of them all their tincture.

As soon as the liquor is become milk-warm, dip your cotton, hank by hank, handling it carefully all the time, and let it steep twenty-four hours. Then wring it carefully and equally, and dry it well without washing.

Step. V. First alum steep.—Dissolve twenty-five pounds of Roman alum in fourteen pails of warm water, without making it boil, scum the liquor well, add two pails of strong barilla water, and then let it cool until it is lukewarm.

Dip your cotton, and handle it hank by hank, and let it steep twenty-four hours; wring it equally, and dry it well without washing.

Step. VI. Second alum steep.—This is in every particular like the last; but after the cotton is dry, steep it six hours in the river, and then wash and dry it.

Step. VII. Dyeing steep.—The cotton is dyed by about ten pounds at once, for which take about two gallons and a half of bullocks' blood, mix it in the copper with twenty-eight pails of milk-warm water, stir it well, add twenty-five pounds of madder, and lastly, stir all well together. Then having beforehand put the cotton on sticks, dip it into the liquor, and move and turn it constantly one hour, during which gradually increase the heat until the liquor begins to boil at the end of the hour. Then sink the cotton, and boil it gently one hour longer; and lastly wash it and dry it.

Take out so much of the boiling liquor, that what remains may produce a milk-warm heat with the fresh water with which the copper is again filled up, and then proceed to make up a dyeing liquor, as above, for the next ten pounds of cotton.

Step. VIII. The fixing steep.—Mix equal parts of the gray steep liquor and of the white steep liquor, taking five or six pails of each. Tread down the cotton into this mixture, and let it steep six hours: then wring it moderately and equally, and dry it without washing.

Step. IX. Brightening steep.—Ten pounds of white soap must be dissolved very carefully and completely in sixteen or eighteen pails of warm water: if any little bits of the soap remain undissolved, they will make spots in the cotton. Add four pails of strong *barilla* water, and stir it well. Sink the cotton in this liquor, keeping it down with cross sticks, and cover it up; boil it gently two hours, then wash it and dry it, and it is finished.

* **Madrepores.** A species of coral, the zoophyte of naturalists. They consist of carbonate of lime, and a little animal membranaceous substance.*

Magistery. Chemists formerly applied this term to almost all precipitates: at present it is applied only to a few, which have retained the name from habitual usage.

Magistery of Bismuth. See Bismuth.

* **Magnesia.** One of the primitive earths, having a metallic basis, called magnesium. It has been found native in the state of hydrate.

Magnesia may be obtained, by pouring into a solution of its sulphate, a solution of subcarbonate of soda, washing the precipitate, drying it, and exposing it to a red heat. It is usually procured in commerce, by acting on magnesian limestone with the impure muriate of magnesia, or bittern of the sea-salt manufactories. The muriatic acid goes to the lime, forming a soluble salt, and leaves behind, the magnesia of both the bittern and limestone. Or the bittern is decomposed by a crude subcarbonate of ammonia, obtained from the distillation of bones in iron cylinders. Muriate of ammonia and subcarbonate of magnesia result. The former is evaporated to dryness, mixed with chalk and sublimed. Subcarbonate of ammonia is thus recovered, with which a new quantity of bittern may be decomposed; and thus in ceaseless repetition, forming an elegant and economical process. 100 parts of crystallized Epsom salt, require for complete decomposition 58 of subcarbonate of potash, or 44 dry subcarbonate of soda, and yield 16 of pure magnesia after calcination.

Magnesia is a white, soft powder. Its sp. gr. is 2.3 by Kirwan. It renders the sirup of violets, and infusion of red cabbage, green, and reddens turmeric. It is infusible, except by the hydroxygen blow-pipe. It has scarcely any taste, and no smell. It is nearly insoluble in water; but it absorbs a quantity of that liquid with the production of heat. And when it is thrown down from the sulphate by a caustic alkali, it is combined with water constituting a hydrate, which, however, separates at a red heat. It contains about one-fourth its weight of water.

When magnesia is exposed to the air, it very slowly attracts carbonic acid. It combines with sulphur, forming a sulphuret.

The metallic basis, or magnesium, may be obtained in the state of amalgam with mercury, by electrization, as is described under Barium; but a much longer time is necessary. Sir H. Davy succeeded also in decomposing magnesia, by passing potassium in vapour through it, heated to whiteness, in a tube of platinum out of the contact of air. He then introduced a small quantity of mercury, and heated it gently for some time in the tube. An amalgam was obtained, which, by distillation, out of the contact of the atmosphere, afforded a dark-gray metallic film, infusible at the point at which plate-glass softened, and which in the process of the distillation of the mercury, rendered the glass black at its point of contact with it. This film burned with a red light when heated strongly, and became converted into a white powder, which had the character of magnesia. When a portion of magnesium was thrown into water, it sunk to the bottom, and effervesced slowly, becoming covered with a white powder. By adding a little muriatic acid to the water, the effervescence was violent. The metal rapidly disappeared, and the solution was found to contain magnesia. No direct experiments have as yet been made, to determine the proportions of the elements in magnesia; but from experiments made on the combination of this substance with sulphuric acid, assuming that they are in single proportions, Dr. Wollaston infers the equivalent of magnesia to be 2.46. Hence magnesium will be 1.46. M. Gay-Lussac has lately experimented, with his characteristic accuracy, on the sulphate of magnesia, and finds it, when crystallized, a compound of

dry sulphate of magnesia,	48.57
water,	51.43

The equivalent number for the dry sulphate is 7.47129, whence that for magnesia is 2.47129, approaching very nearly to Dr. Wollaston's determination.

When magnesia is strongly heated in contact with 2 volumes of chlorine, this gas is absorbed, and 1 volume of oxygen is disengaged. Hence it is evident that there exists a combination of magnesium and chlorine, or a true chloride. The salt called muriate of magnesia, is a compound of the chloride and water. When it is acted on by a strong heat, by far the greatest part of the chlorine unites to the hydrogen of the water, and rises in the form of muriatic acid gas; while the oxygen of the decomposed water, combines with the magnesium to form magnesia.

Magnesia is often associated with lime in minerals, and their perfect separation becomes an interesting problem in analysis. M. Longchamp has published a valuable paper on the subject, in the 12th volume of the *Ann. de Chim. et Phys.*

He considers subcarbonate of ammonia as the best reagent for separating the two earths. Care must be taken to filter the solution from the calcareous precipitate, shortly after the addition of the subcarbonate. If it stand 12 or 18 hours, subcarbonate of magnesia falls with the carbonate of lime. 100 parts of solution of pure muriate of lime gave, with subcarbonate of ammonia, 1.5475 parts of carbonate of lime: 100 of the same solution, previously mixed with muriate of magnesia in excess, yielded 1.5585 parts. Alkaline subcarbonates dissolve the subcarbonate of magnesia; but caustic potash precipitates magnesia perfectly, either with or without heat. He objects to the method of separating these earths, by first converting them into sulphates; first, on account of the great difficulty of driving off the water from the sulphates of magnesia; secondly, from the difficult solubility of heated and dry sulphate of magnesia in water; and, thirdly, because the sulphate of magnesia is partly decomposed at very high heats.

Magnesia is chiefly used as an antacid, purgative, and lithontriptic in medicine. When incautiously used for a long time, it may produce very serious evils, of which a remarkable case is narrated by Mr. Brande, in the 1st volume of his Journal. A lady was recommended to take magnesia, in consequence of some very severe nephritic attacks, accompanied with the passage of gravel. She was desired to take a tea-spoonful every night; and Henry's calcined magnesia was preferred, as that always operated upon the bowels, and "carried itself off," which other magnesia did not, but, on the contrary, felt heavy and uneasy in the stomach. The dose was gradually increased to two tea-spoonfuls, in order to produce effect upon the bowels, which this quantity never failed to do. The symptoms for which it was ordered, were soon removed, but the plan was persevered in for two years and a half, with little intermission; so that as the average weight of a tea-spoonful is at least 40 grains, and the average dose was a tea-spoonful and a half, it may be presumed that she took, during the above period, between 9 and 10 pounds troy. "In the course of the last autumn, she became sensible of a tenderness in the left side, just above the groin, connected with a deep seated tumour, obscurely to be felt upon pressure, and subject to attacks of constipation, with painful spasmodic action of the bowels, tenesmus, and a highly irritable state of stomach. These attacks recurred every two or three weeks, varying in violence, but requiring the use of active remedies. Several irregular lumps, of a soft light brown substance, were voided, having the appearance of a large mass broken down, and when dry extremely friable. A part of each was subjected to analysis, and found to consist entirely of subcarbonate of magnesia, concreted by the mucus of the bowels, in the proportion of about 40 per cent. She was cured by the use of other purgatives." Another case is mentioned, in which not only large quantities of a concretion of a similar description were voided, but upon examination after death, which took place perhaps six months after any magnesia had been taken, a collection, supposed to be from four to six pounds, was found imbedded in the head of the colon, which was of course much distended.

The most important magnesian salts are described under the acids.*

* MAGNESIA (HYDRATE OF). This mineral was found by Dr. Bruce of New York, in small veins in serpentine at Hoboken, in New Jersey. Colour white. Massive. Lustre pearly. Fracture foliated or radiated. Semi-transparent in the mass; transparent in single folia. Soft, and somewhat elastic. Adheres slightly to the tongue. Sp. gr. 2.13. Soluble in acids. Its constituents are magnesia 70, water 30, which approaches to 1 prime equivalent of each.—*Jameson.**

* MAGNESIAN LIMESTONE. See DOLOMITE.*

* MAGNESITE. Colour yellowish-gray, or yellowish-white, and marked with spots. It occurs massive, tuberose, reniform, and vesicular. Surface rough. Dull. Fracture conchoidal. Fragments rather sharp-edged. Opaque. Scratched by fluor spar, but it scratches calcareous spar. It adheres pretty strongly to the tongue. It feels rather meagre. Streak dull. Rather easily frangible. Sp. gr. 2.881. Infusible; but before the blow-pipe it becomes so hard as to scratch glass. Its constituents are, 46 magnesia, 51 carbonic acid, 1 alumina, 0.25 ferruginous manganese, 0.16 lime, 1 water. —*Bucholz*. It is found at Hrubschitz in Moravia, in serpentine rocks.*

* MAGNETIC IRON ORE, and PYRITES. See ORES OF IRON.*

* MALACHITE. See ORES OF COPPER.*

* **Malacolite.** Sahlite.*

* **Malates** and **Malic Acid.** See Acid (Sorbic).

* **Malleability.** See Ductility.*

* **Maltha.** The mineral tallow of Kirwan, said to have been found on the coast of Finland. It resembles wax. Its sp. gr. is 0.77. It is white, brittle, stains paper like oil, melts with a moderate heat, and burns with a blue flame and much smoke. It dissolves readily in oil, and imperfectly in hot alcohol.*

Manganese. A metal of a dull whitish colour when broken, but which soon grows dark by oxidation, from the action of the air. It is hard, brittle, though not pulverizable, and rough in its fracture; so difficultly fusible that no heat yet exhibited has caused it to run into masses of any considerable magnitude. Its sp. gr. is 8.0. When broken in pieces, it falls into a powder by spontaneous oxidation.

* Manganese heated in oxygen, or chlorine, takes fire and forms an oxide or chloride. It is difficult to decide on the oxides of manganese.

According to Sir H. Davy there are two oxides only, the olive and the black; Mr. Brande has three, the olive, dark-red, and black; M. Thenard has four, the green, the white (in the state of hydrate), the chesnut-brown, and the black; Berzelius has five, the first gray, the second green, the third and fourth are not well defined, and the fifth is the black.

In this perplexity it will be prudent to rest on the authority of Sir H. Davy.

1. The first oxide may be obtained by dissolving common black manganese in sulphuric or nitric acid, adding a little sugar, and precipitating by solution of potash. A white power is obtained, which being heated to redness out of the contact of air, becomes yellow, puce-coloured, and lastly red-brown. To be preserved, it should be washed in boiling water, previously freed from air, and then dried by distilling off the moisture in a retort filled with hydrogen. The dark olive oxide, when examined in large quantities, appears almost black; but when spread upon white paper, its olive tint is apparent. It takes fire when gently heated, increases in weight, and acquires a browner tint. It slowly absorbs oxygen from the air, even at common temperatures. It dissolves in acids without effervescence. The white powder obtained above, is the hydrated protoxide. The different tints which it assumes by exposure to air, are ingeniously supposed by Sir H. Davy, to depend on the formation of variable quantities of the black-brown oxide, which probably retains the water contained in the white hydrate, and is hence deep puce-coloured.

2. The black *peroxide.* Its sp, gr. is 4. It does not combine with any of the acids. It yields oxygen when heated; and by intense ignition passes in a great measure into the protoxide. According to Sir H. Davy, the olive oxide consists of

Manganesium, -	79
Oxygen, - - -	21

And the black oxide, of

Manganesium, - -	69
Oxygen, about - -	31

He considers the first as a deutoxide, whence the prime equivalent is inferred to be 7.533.

The olive oxide,	7.533 met.	+ 2 ox.
Or, - - -	80.	+ 20.
The black oxide will be,	7.533	+ 3.
Or, - - -	71.5	+ 28.5.
The compound of the first with water is a deutohydrate, or	7.533	+ 2.25w.

The olive oxide becomes green by the action of potash, whence Sir H. accounts for the mistakes of chemists relative to a green oxide. In this case there is a combination. See Cameleon Mineral.

Dr. Thomson pitches on the number 3.5 for the atom of manganese, from the researches of John and Berzelius. The confidence due to his authority in this case may be judged of from the following narrative: "Dr. John acknowledges, that his analyses of these oxides is by no means to be depended on. Berzelius's statement is rather theoretical than experimental. He even doubts of the existence of his first oxide, the only one he examined; and he has advanced no proof that there exists any difference between his second and third oxide."—"Hence it is evident, that protoxide (the green oxide of John) of manganese is composed of

Manganese,	3.5	100
Oxygen,	1.	28.75

"This very nearly coincides with Berzelius's third oxide. And in reality his third oxide is the *protoxide* of manganese." *System*, vol. i. pp. 403 and 404. 5th ed.

He takes his proportions in the peroxide, from Berzelius's "theoretical considerations," to the exclusion of Sir H. Davy's "experiments." The perchloride may be conveniently obtained by igniting the muriate of manganese. It thus appears as a pale pink-coloured substance, semi-transparent, and in brilliant scales. It is a compound of 7.533 metal + 9 chlorine, from the experiments of Dr. John Davy. Probably a protochloride may be formed.

Sir H. Davy is inclined to believe, that the olive oxide is the only one which enters into combination with vitrifiable substances.

The salts of manganese have been little studied. They are mostly soluble in water. Ferroprussiate of potash gives a white precipitate.

Hydrosulphuret, - -	white
Sulphuretted hydrogen, .	0
Gallic acid, - - -	0
Succinate and benzoate of am.	0*

Concentrated sulphuric acid attacks manganese, at the same time that hydrogen gas is disengaged. If sulphuric acid be added, and drawn off by distillation several times from the black oxide, by a heat nearly approaching to ignition, in a glass vessel, it is found, that oxygen gas is disengaged toward the end of each process, and part of the oxide is dissolved. The solution of the sulphate made from the metal itself is colourless. If it be made from the black oxide, it is a purplish-red; but this colour is destroyed by the light of the sun, and again restored by removing the solution into the dark.

Sulphurous acid dissolves the oxide, taking part of its oxygen, which converts it into sulphuric acid, and thus forming a sulphate with the remaining oxide.

Nitric acid dissolves manganese with effervescence, and the escape of nitrous gas. A spongy, black, and friable matter remains, which is a carburet of iron. The solution does not afford crystals. The oxide is more readily soluble in nitrous acid.

Manganese is dissolved in the usual manner by muriatic acid. The solution of manganese in muriatic acid scarcely affords crystals; but a deliquescent saline mass by evaporation, which is soluble in alcohol.

In the dry way, the oxide of manganese combines with such earths and saline substances as are capable of undergoing fusion in a strong heat. These experiments are most advantageously performed by the blow-pipe, which see.

This metal melts readily with most of the other metals, but rejects mercury. Gold and iron are rendered more fusible by a due addition of manganese; and the latter metal is rendered more ductile. Copper becomes less fusible, and is rendered whiter, but of a colour subject to tarnish.

The ore of manganese, which is known in Derbyshire by the name of *black wadd*, is remarkable for its spontaneous inflammation with oil. It is of a dark brown colour, of a friable earthy appearance, partly in powder, and partly in lumps. If half a pound of this be dried before a fire, and afterward suffered to cool for about an hour; and it be then loosely mixed or kneaded with two ounces of linseed oil; the whole, in something more than half an hour, becomes gradually hot, and at length bursts into flame. This effect wants explanation. It seems, in some measure, to resemble the inflammation of oils by the nitric acid.

Manganese was used chiefly by glass-makers and potters; but the important discovery of chlorine has greatly extended its utility. See BLEACHING.*

MANNA. Several vegetables afford manna; but the ash, the larch, and the alhagi, afford it in the largest quantities.

The ash which affords manna grows naturally in all temperate climates; but Calabria and Sicily appear to be the most natural countries to this tree.

The manna flows naturally from this tree, and attaches itself to its sides in the form of white transparent drops; but the extraction of this juice is facilitated by incisions made in the tree during summer.

Its smell is strong, and its taste sweetish and slightly nauseous; if exposed on hot coals, it swells up, takes fire, and leaves a light bulky coal.

Water totally dissolves it, whether hot or cold. If it be boiled with lime, clarified with white of egg, and concentrated by evaporation, it affords crystals of sugar.

Manna affords, by distillation, water, acid, oil, and ammonia; its coal affords fixed alkali.

This substance forms the basis of many purgative medicines.

* **MANURES.** Animal and vegetable matters introduced into the soil, to accelerate vegetation, and increase the production of crops. They have been used since the earliest periods of agriculture. But the manner in which manures act, the best manner of applying them, and their relative value and durability, were little understood, till the great chemist who gave new lustre to the whole science, turned his mind to this, its darkest, but most important application. I conceive it will be doing a service to society, to aid the diffusion of the light springing from the invaluable researches of Sir H. Davy, by inserting the following short abstract from his Agricultural Chemistry.

The pores in the fibres of the roots of plants are so small, that it is with difficulty they can be discovered by the microscope; it is not therefore probable, that solid substances can pass into them from the soil. He tried an experiment on this subject: some impalpable powdered charcoal procured by washing gunpowder, and dissipating the sulphur by heat, was placed in a phial containing pure water, in which a plant of peppermint was growing; the roots of the plant were pretty generally in contact with the charcoal. The experiment was made in the beginning of May 1805; the growth of the plant was very vigorous during a fortnight, when it was taken out of the phial; the roots were cut through in different parts; but no carbonaceous matter could be discovered in them, nor were the smallest fibrils blackened by charcoal, though this must have been the case had the charcoal been absorbed in a solid form

No substance is more necessary to plants than carbonaceous matter; and if this cannot be introduced into the organs of plants except in a state of solution, there is every reason to suppose, that other substances less essential will be in the same case.

He found by some experiments made in 1804, that plants introduced into strong fresh solutions of sugar, mucilage, tanning principle, jelly, and other substances, died; but that plants lived in the same solutions after they had fermented. At that time, he supposed that fermentation was necessary to prepare the food of plants; but he afterwards found, that the deleterious effect of the recent vegetable solutions, was owing to their being too concentrated; in consequence of which the vegetable organs were probably clogged with solid matter, and the transpiration by the leaves prevented. In the beginning of June, in the next year, he used solutions of the same substances, but so much diluted, that there was about only one two-hundredth part of solid vegetable or animal matter in the solutions. Plants of mint grew luxuriantly in all these solutions; but least so in that of the astringent matter. He watered some spots of grass in a garden with the different solutions separately, and a spot with common water: the grass watered with solutions of jelly, sugar, and mucilage, grew most vigorously; and that watered with the solution of the tanning principle grew better than that watered with common water.

Vegetable and animal substances deposited in the soil, as is shown by universal experience, are *consumed* during the process of vegetation; and they can only nourish the plant by affording solid matters capable of being dissolved by water, or gaseous substances capable of being absorbed by the fluids in the leaves of vegetables; but such parts of them as are rendered gaseous, and that pass into the atmosphere, must produce a comparatively small effect, for gases soon become diffused through the mass of the surrounding air. The great object in the application of manure, should be to make it afford as much soluble matter as possible to the roots of the plant; and that in a slow and gradual manner, so that it may be entirely consumed in forming its sap and organized parts.

Whenever manures consist principally of matter soluble in water, it is evident that their fermentation or putrefaction should be prevented as much as possible; and the only cases in which these processes can be useful, are when the manure consists principally of vegetable or animal *fibre*. The circumstances necessary for the putrefaction of animal substances, are similar to those required for the fermentation of vegetable substances; a temperature above the freezing point, the presence of water, and the presence of oxygen, at least in the first stage of the process.

To prevent manures from decomposing, they should be preserved dry, defended from the contact of air, and kept as cool as possible.

All *green succulent plants* contain saccharine or mucilaginous matter, with woody fibre, and readily ferment. They cannot, therefore, if intended for manure, be used too soon after their death.

Rape-cake, which is used with great success as a manure, contains a large quantity of mucilage, some albuminous matter, and a small quantity of oil. This manure should be used recent, and kept as dry as possible before it is applied. It forms an excellent dressing for turnip crops; and is most economically applied by being thrown into the soil at the same time with the seed. Whoever wishes to see this practice in its highest degree of perfection, should attend Mr. Coke's annual sheep-shearing, at Holkham.

Sea-weeds, consisting of different species of fuci, algæ, and confervæ, are much used as a manure on the sea coasts of Britain and Ireland. This manure is transient in its effects, and does not last for more than a single crop, which is easily accounted for from the large quantity of water, or the elements of water, it contains. It decays without producing heat when exposed to the atmosphere, and seems, as it were, to melt down and dissolve away. He has seen large heaps entirely destroyed in less than two years, nothing remaining but a little black fibrous matter.

The best farmers in the west of England use it as fresh as it can be procured; and the practical results of this mode of applying it are exactly conformable to the theory of its operation.

When straw is made to ferment, it becomes a more manageable manure; but there is likewise, on the whole, a great loss of nutritive matter. More manure is perhaps supplied for a single crop; but the land is less improved than it would be, supposing the whole of the vegetable matter could be finely divided and mixed with the soil.

Lord Meadowbank states, that one part of dung is sufficient to bring three or four parts of peat into a state in which it is fitted to be applied to land; but of course the quantity must vary according to the nature of the dung and of the peat. In cases in which some living vegetables are mixed with the peat, the fermentation will be more readily effected.

Manures, from animal substances, in general, require no *chemical* preparation to fit them for the soil. The great object of the farmer is to blend them with the earthy constituents in a proper state of division, and to prevent their too rapid decomposition.

Fish forms a powerful manure, in whatever state it is applied; but it cannot be ploughed in too fresh, though the quantity should be limited. Mr. Young records an experiment, in which herrings spread over a field, and ploughed in for wheat, produced so rank a crop, that it was entirely laid before harvest.

Bones are much used as a manure in the neighbourhood of London. After being broken, and boiled for grease, they are sold to the farmer. The more divided they are, the more powerful are their effects. The expense of grinding them in a mill would probably be repaid by the increase of their fertilizing powers; and in the state of powder they might be used in the drill husbandry, and delivered with the seed, in the same manner as rape-cake.

During the putrefaction of urine the greatest part of the soluble animal matter that it contains is destroyed. it should consequently be used as fresh as possible; but if not mixed with solid matter, it should be diluted with water, as when pure it contains too large a quantity of animal matter to form a proper fluid nourishment for absorption by the roots of plants.

Putrid urine abounds in ammoniacal salts; and though less active than fresh urine, is a very powerful manure.

Amongst excrementitious solid substances used as manures, one of the most powerful is the *dung* of *birds* that feed on *animal* food, particularly the dung of sea birds. The *guano*, which is used to a great extent in South America, and which is the manure that fertilizes the sterile plains of Peru, is a production of this kind.

It contains a fourth part of its weight of uric acid, partly saturated with ammonia, and partly with potash; some phosphoric acid combined with the bases, and likewise with lime. Small quantities of sulphate and muriate of potash, a little fatty matter, and some quartzose sand.

Night-soil, it is well known, is a very powerful manure, and very liable to decompose.

The disagreeable smell of night-soil may be destroyed by mixing it with quicklime; and if exposed to the atmosphere in thin layers strewed over with quicklime in fine weather, it speedily dries, is easily pulverized, and in this state may be used in the same manner as rape-cake, and delivered into the furrow with the seed

The Chinese, who have more practical knowledge of the use and application of manures than any other people existing, mix their night-soil with one-third of its weight of a fat marl, make it into cakes, and dry it by exposure to the sun. These cakes, we are informed by the French missionaries, have no disagreeable smell, and form a common article of commerce of the empire.

After night-soil, *pigeons' dung* comes next in order, as to fertilizing power.

If the pure dung of cattle is to be used as manure, like the other species of dung which have been mentioned, there seems no reason why it should be made to ferment except in the soil; or if suffered to ferment, it should be only in a very slight degree. The grass in the neighbourhood of recently voided dung, is always coarse and dark green; some persons have attributed this to a noxious quality in unfermenting dung; but it seems to be rather the result of an excess of food furnished to the plants.

A slight incipient fermentation is undoubtedly of use in the dunghill; for by means of it a disposition is brought on in the woody fibre to decay and dissolve, when it is carried to the land, or ploughed into the soil; and woody fibre is always in great excess in the refuse of the farm.

Too great a degree of fermentation is, however, very prejudicial to the composite manure in the dunghill; it is better that there should be no fermentation at all before the manure is used, than that it should be carried too far.

Within the last seven years, Mr. Coke has entirely given up the system formerly adopted on his farm, of applying fermented dung; and he has found, that his crops have been since as good as they ever were, and that his manure goes nearly twice as far.

In cases when farm-yard dung cannot be immediately applied to crops the destructive fermentation of it should be prevented very carefully.

The surface should be defended as much as possible from the oxygen of the atmosphere; a compact marl, or a tenacious clay, offers the best protection against the air; and before the dung is covered over, or, as it were, sealed up, it should be dried as much as possible. If the dung is found at any time to heat strongly, it should be turned over, and cooled by exposure to air.

If a thermometer plunged into the dung does not rise to above 100 degrees of Fahr. there is little danger of much aëriform matter flying off. If the temperature is higher, the dung should be immediately spread abroad.

When a piece of paper moistened in muriatic acid held over the steams arising from a dunghill gives dense fumes, it is a certain test that the decomposition is going too far, for this indicates that volatile alkali is disengaged.

When dung is to be preserved for any time, the situation in which it is kept is of importance. It should, if possible, be defended from the sun. To preserve it under sheds would be of great use; or to make the site of a dunghill on the north side of a wall.

Soot, which is principally formed from the combustion of pit-coal or coal, generally contains likewise substances derived from animal matters. This is a very powerful manure.

It is well fitted to be used in the dry state, thrown into the ground with the seed, and requires no preparation. Lime should never be applied with animal manures, unless they are too rich, or for the purpose of preventing noxious effluvia. It is injurious when mixed with any common dung, and tends to render the extractive matter insoluble.

"The doctrine of the proper application of manures from organized substances," says this eloquent writer, "offers an illustration of an important part of the economy of nature, and of the happy order in which it is arranged.

"The death and decay of animal substances tend to resolve organized forms into chemical constituents; and the pernicious effluvia disengaged in the process, seem to point out the propriety of burying them in the soil, where they are fitted to become the food of vegetables. The fermentation and putrefaction of organized substances in the free atmosphere, are noxious processes; beneath the surface of the ground they are salutary operations. In this case, the food of plants is prepared where it can be used; and that which would offend the senses and injure the health, if exposed, is converted by gradual processes into forms of beauty and of usefulness; the fetid gas is rendered a constituent of the aroma of the flower, and what might be poison, becomes nourishment to animals and to man."*

* **Marble.** See **Limestone.***

Marcasite. See **Pyrites.**

Marl. See **Limestone.**

Marmor Metallicum. Native sulphate of barytes.

***Mars.** The mythological and alchemistical name of iron.*

Mass'cot. Yellow oxide of lead. See **Lead.**

Mastic. A resinous substance in the form of tears, of a very pale yellow colour, and farinaceous appearance, having little smell, and a bitter astringent taste. It flows naturally from the tree, but its produce is accelerated by incisions. The lesser turpentine tree and the lentiscus afford the mastic of commerce.

No volatile oil is obtained from this substance when distilled with water. Pure alcohol and oil of turpentine dissolve it; water scarcely acts upon it; though by mastication it becomes soft and tough, like wax. When chewed a little while, however, it is white, opaque, and brittle, so as not to be softened again by chewing. The part insoluble in alcohol much resembles in its properties caoutchouc. It is used in fumigations, in the compositions of varnishes, and is supposed to strengthen the gums.

Matrass. See **Laboratory.**

Matrix. The earthy or stony matter which accompanies ores, or envelopes them in the earth.

Meadow-ore.** Conchoidal **Bog Iron-ore.

Measures. The English measures of capacity are according to the following table;

One gallon, wine measure, is equal to	four quarts.
One quart, -	two pints.
One pint, - -	28.875 cubic inches.

The pint is subdivided by chemists and apothecaries into 16 ounces.

The gallon, quart, and pint, ale measure, are to the measures of the same denominations, wine measure, respectively, as 282 to 231. See **Acid (Muriatic).**

The Paris foot is equal to 12.789 English inches, or to the English foot as 114 to 107. For measures of weight, see **Balance.**

* **Meerschaum.** Keffekil of Kirwan. Colours, yellowish and grayish-white. Massive. Dull. Fracture fine earthy. Fragments angular. Opaque. Streak slightly shining. Does not soil. Very soft, sectile, but rather difficultly frangible. Adheres strongly to the tongue. Feels rather greasy. Sp. gr. 1.2 to 1.6. Before the blow-pipe, it melts on the edges into a white enamel. Its constituents are, silica 41.5, magnesia 18.25, lime 0.50, water and carbonic acid 39.—*Klaproth.* It occurs in the veins in the serpentine of Cornwall. When first dug, it is soft, greasy, and lathers like soap. Hence the Tartars use it for washing clothes. In Turkey it is made into tobacco-pipes, from meerschaum dug in Natolia, and near Thebes. See Jameson's mineralogy for an entertaining account of the manufacture.*

* **Meionite.** Prismato-pyramidal feldspar. Colour, grayish-white. Massive, but more frequently crystallized. The primitive form is a pyramid, in which the angles are 136° 22′, 63° 22′. Its secondary forms are, rectangular four-sided prisms, variously acuminated or truncated. The crystals are small, smooth and splendent. Lustre vitreous. Cleavage, double rectangular. Transparent. Harder than common feldspar, but softer than quartz. Easily frangible. Sp. gr. 2.6. Easily fusible before the blowpipe, with intumescence. It occurs along with ceylanite and nepheline, in granular limestone, at Monte Somma near Naples.*

* **Melanite.** Colour, velvet-black. In roundish grains, but more frequently crystallized in a rhomboidal dodecahedron, truncated on all the edges. Surface of the grains rough and uneven; that of the crystals shining. Fracture flat conchoidal. Opaque. As hard as quartz. Rather easily frangible. Sp. gr. 3.73. Its constituents are, silica 35.5, alumina 6, lime 32.5, oxide of iron 25.25, oxide of manganese 0.4, loss 0.35. It is found in a rock at Frescati near Rome, and in the basalt of Bohemia.*

* **Mellates.** Compounds of mellitic acid with the salifiable bases.*

* **Mellite,** or **Honey-stone.** Colour honey-yellow. Rarely massive. Crystallized. Its primitive figure is a pyramid of 118° 4′, and 93° 22′. The secondary figures are; the primitive, truncated on the apices; on the apices and angles of the common base; and the angles on the common base bevelled. Externally smooth and splendent. Cleavage pyramidal. Fracture perfect conchoidal. Semi-transparent. Refracts double, in the direction of the pyramidal plane. Harder than gypsum, but softer than calcareous spar. Brittle. Sp. gr. 1.4 to 1.6. Before the blow pipe, it becomes white and opaque, with black spots, and is at length reduced to ashes, when heated in a close vessel, it becomes black. It is slightly resino-

electric by friction. Its constituents are, alumina 16, mellitic acid 46, water of crystallization 38.—*Klaproth* It occurs superimposed on bituminous wood, and earth coal, and is usually accompanied with sulphur. It has hitherto been found only at Artern in Thuringia.*

* **Melting.** See Caloric, *change of state*.*

* **Menachanite.** Colour grayish-black. Occurs only in very small flattish angular grains, which have a rough glimmering surface. Glistening; adamantine, or semi-metallic lustre. Cleavage, imperfect. Opaque, Not so hard as magnetic iron-sand. Brittle. Retains its colour in the streak. Sp. gr. 4.3 to 4.4. It is attractible by the magnet, but in a much weaker degree, than magnetic iron-stone. Infusible without addition. It tinges borax of a greenish colour. Its constituents are oxide of iron 51, oxide of titanium 45.25, oxide of manganese 0.25, silica 3.5.—*Klaproth.* It is found, accompanied with fine quartz-sand, in the bed of a rivulet which enters the valley of Manaccan in Cornwall.*

* **Menilite.** A sub-species of indivisible quartz. It is of two kinds; the brown and the gray. *Brown menilite* is chesnut-brown, inclining to liver-brown. It occurs tuberose. External surface, rough and dull; internal glistening. It has sometimes a tendency to lamellar distinct concretions. Fracture very flat conchoidal. Translucent on the edges. Scratches glass. Easily frangible. Sp. gr. 2.17. Infusible. Its constituents are, silica 85.5, alumina 1, lime 0.5, oxide of iron 0.5, water and carbonaceous matter 11.0. Found at Menil Montant near Paris, imbedded in adhesive slate, as flint is in chalk.

Gray Menilite. Colour yellowish-gray. Tuberose. Internally glimmering or dull. Fracture as above. Semi-hard in a high degree. Easily frangible. Sp. gr. 2.3. It occurs at Argenteuil near Paris, imbedded in a clayey marl.—*Jameson.**

* **Mephitic Acid.** Carbonic Acid.*

Menstruum. A word synonymous with solvent.

Mercury is distinguished from all other metals by its extreme fusibility, which is such, that it does not take the solid state until cooled to the thirty-ninth degree below 0 on Fahrenheit's thermometer; and of course it is always fluid in the temperate climates of the earth. Its colour is white, and rather bluer than silver. In the solid state it is malleable;§ its specific gravity is 13.6. It is volatile, and rises in small portions at the common temperature of the atmosphere, as is evinced by several experiments, more especially in a vacuum, such as obtains in the upper part of a barometer tube. At the temperature of about 656°, it boils rapidly, and rises copiously in fumes. When exposed to such a heat as may cause it to rise quickly in the vaporous form, or about 600°, it gradually becomes converted into a red oxide, provided oxygen be present. This was formerly known by the name of precipitate *per se*. A greater heat, however, revives this metallic oxide, at the same time that the oxygen is again extricated. Ten days or a fortnight's constant heat is required to convert a few grains of mercury into precipitate *per se* in the small way.

From this volatility of mercury, it is commonly purified by distillation.

Mercury is not perceptibly altered by mere exposure to the air; though by long agitation, with access of air, it becomes converted into a black powder or oxide, which gives out oxygen by heat, the metal being at the same time revived.

* When calomel or protochloride of mercury is acted on by potash-water, it yields the pure black protoxide; and when corrosive sublimate or the deutochloride is treated in the same way, it affords the red deutoxide. The former oxide, heated with access of air, slowly changes into the latter. The constituents of the first are 100 metal + 4 oxygen; of the second 100 + 8. Hence the prime equivalent of mercury is 25. At a red heat both oxides emit their oxygen, and pass to the metallic state. A moderate heat converts the black oxide, partly into running mercury, and partly into red oxide. The deutoxide, as usually prepared from the nitrate by gentle calcination, is in brilliant red scales, which become of an orange hue when finely comminuted. It frequently contains a little undecomposed subnitrate.

By triturating mercury with unctuous or viscid matters, it is changed partly into protoxide, and partly into very minute globules. By exposing mercurial ointment to a moderate heat, the globules fall down, while a proportion of the oxide remains combined with the grease. This light gray chemical compound is supposed to possess all the virtues of the dark coloured ointment, and to be cheaper and more convenient in the application. Mr. Donovan, who introduced it, forms it directly by exposing a mixture of 1 part of black oxide, and 24 parts of hogs' lard, to a heat of 350°, for about two hours.

Red oxide of mercury is acrid and poisonous, and carries these qualities into its saline combinations. The protoxide is relatively bland, and is the basis of all the mild mercurial medicines.

1. When mercury is heated in chlorine, it burns with a pale red flame, and the substance called corrosive sublimate is formed. This *deutochloride* may also be formed by mixing together equal parts of dry bi-deutosulphate of mercury and common salt, and subliming. The corrosive sublimate rises,

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§ The reader will find an ample account of the freezing of quicksilver in Dr. Blagden's History, vol. lxxxiii. of the Philosophical Transactions.

and incrusts the top of the vessel, in the form of a beautiful white semi-transparent mass, composed of very small prismatic needles. It may be obtained in cubes, and rhomboidal prisms, or quadrangular prisms, with their sides alternately narrower, and terminated by dihedral summits. Its sp. gr. is 5.14. Its taste is acrid, stypto-metallic, and eminently disagreeable. It is a deadly poison. Twenty parts of cold water dissolve it, and less than one of boiling water. 100 parts of alcohol at the boiling temperature dissolve 88 of corrosive sublimate; and at 70° they dissolve 37.5 parts. The constituents of this chloride are,—

Mercury,	25	73.53
Chlorine,	9	26.47

It may be recognized by the following characters: It volatilizes in white fumes, which seem to tarnish a bright copperplate, but really communicate a coating of metallic mercury, which appears glossy white on friction. When caustic potash is made to act on it, with heat, in a glass tube, a red colour appears, which by gentle ignition vanishes, and metallic mercury is then found to line the upper part of the tube in minute globules. Solution of corrosive sublimate reddens litmus paper; but changes sirup of violets to green. Bicarbonate of potash throws down from it a deep brick-red precipitate, from which metallic mercury may be procured by heating it in a tube. Caustic potash gives a yellow precipitate; but if the solution be very dilute, a white cloud only is occasioned, which becomes yellowish-red on subsidence. Lime-water causes a deep yellow, verging on red. Water of ammonia forms a white precipitate, which becomes yellow on being heated. With sulphuretted hydrogen and hydrosulphurets, a black or blackish-brown precipitate appears. Nitrate of silver throws down the curdy precipitate characteristic of muriatic acid; and the protomuriate of tin gives a white precipitate. The proper antidote to the poison of corrosive sublimate, is the white of egg or albumen, which converts it into calomel. Sulphuretted hydrogen water may also be employed, along with emetics. From six to twelve grains were the mortal doses employed by Orfila in his experiments on dogs. They died in horrible convulsions generally in two hours. But when, with the larger quantity, the whites of eight eggs were thrown into the stomach, the animals soon recovered, after vomiting. Corrosive sublimate, digested with albumen for some time, was given in considerable doses, with impunity. The instructions given under arsenic, for examination of the bowels of a person supposed to be poisoned, are equally applicable to poisoning by corrosive sublimate; and the appearances are much the same.

2. *Protochloride* of mercury, *mercurius dulcis*, or *calomel*, is usually formed from the deutochloride, by triturating four parts of the latter with three of quicksilver, till the globules disappear, and subjecting the mixture to a subliming heat. By levigating and edulcorating with warm water the sublimed grayish-white cake, the portion of soluble corrosive sublimate which had escaped decomposition is removed. It may also be made by adding solution of protonitrate of mercury to solution of common salt. The protochloride or calomel precipitates. The following is the process used at Apothecaries' Hall, London; 50 lbs. of mercury are boiled with 70 lbs. of sulphuric acid, to dryness, in a cast-iron vessel; 62 lbs. of the dry salt are triturated with 40½ lbs. of mercury, until the globules disappear, and 34 lbs. of common salt are then added. This mixture is submitted to heat in earthen vessels, and from 95 to 100 lbs. of calomel are the result. It is washed in large quantities of distilled water, after having been ground to a fine and impalpable powder.

When protochloride of mercury is very slowly resublimed, four-sided prisms, terminated by pyramids, are obtained. It is nearly tasteless and insoluble, and is purgative in doses of five or six grains. Its sp. gr. is 7.176. Exposure to air darkens its surface. When two pieces are rubbed in the dark, they phosphoresce. It is not so volatile as the deutochloride. Nitric acid dissolves calomel, converting it into corrosive sublimate. Protochloride of mercury is composed of

Mercury,	25.	84.746
Chlorine,	4.5	15.254

We have also two sulphurets of mercury; the black or *ethiops mineral*; and the red or *cinnabar*.

The first is easily made by heating or triturating the ingredients together, or by adding a hydrosulphuret of alkali to a mercurial saline solution. It consists of

Mercury,	25	92.6
Sulphur,	2	7.4

When the black sulphuret is exposed to a red heat in earthen pots, cinnabar sublimes, which, when reduced to powder, is of a beautiful red colour, and is used as a pigment under the name of *vermilion*. Its sp. gr. is about 10. It is insoluble, insipid, and burns with a blue flame. If it be mixed with half its weight of iron filings, and distilled in a retort, it yields pure mercury. It is deutosulphuret, and consists of

Mercury,	25	86.2
Sulphur,	4	13.8

The salts of mercury have the following general characters:—

1. A dull red heat volatilizes them.
2. Ferroprussiate of potash gives a white precipitate.
3. Hydrosulphuret, black.
4. Muriate of soda, with the protosalts, white.
5. Gallic acid, orange-yellow.

6. Plate of copper, quicksilver.*

The sulphuric acid does not act on this metal, unless it be well concentrated and boiling. For this purpose mercury is poured into a glass retort, with nearly twice its weight of sulphuric acid. As soon as the mixture is heated, a strong effervescence takes place, sulphurous acid gas escapes, the surface of the mercury becomes white, and a white powder is produced: when the gas ceases to come over, the mercury is found to be converted into a white, opaque, caustic, saline mass, at the bottom of the retort, which weighs one-third more than the mercury, and is decomposed by heat. Its fixity is considerably greater than that of mercury itself. If the heat be raised, it gives out a considerable quantity of oxygen, the mercury being at the same time revived.

Water resolves it into two salts, the bisulphate and subsulphate; the latter is of a yellow colour. Much washing is required to produce this colour, if cold water be used; but if a large quantity of hot water be poured on, it immediately assumes a bright lemon colour. In this state it is called *turpeth mineral.* The other affords, by evaporation, small, needly, deliquescent crystals.

The fixed alkalis, magnesia, and lime precipitate oxide of mercury from its solutions; these precipitates are reducible in closed vessels by mere heat without addition.

The nitric acid rapidly attacks and dissolves mercury, at the same time that a large quantity of nitrous gas is disengaged; and the colour of the acid becomes green during its escape. Strong nitric acid takes up its own weight of mercury in the cold; and this solution will bear to be diluted with water. But if the solution be made with the assistance of heat, a much larger quantity is dissolved; and a precipitate will be afforded by the addition of distilled water, which is of a yellow colour if the water be hot, or white if it be cold; and greatly resembles the turpeth mineral produced with sulphuric acid; it has accordingly been called *nitrous turpeth.*

All the combinations of mercury and nitric acid are very caustic, and form a deep purple or black spot upon the skin. They afford crystals, which differ according to the state of the solution. When nitric acid has taken up as much mercury as it can dissolve by heat, it usually assumes the form of a white saline mass. When the combination of nitric acid and mercury is exposed to a gradual and long continued low heat, it gives out a portion of nitric acid, and becomes converted into a bright red oxide, still retaining a small portion of acid. This is known by the name of *red precipitate,* and is much used as an escharotic.

When red precipitate is strongly heated, a large quantity of oxygen is disengaged, together with some nitrogen, and the mercury is sublimed in the metallic form.

Nitrate of mercury is more soluble in hot than cold water, and affords crystals by cooling. It is decomposed by the affusion of a large quantity of water, unless the acid be in excess.

A fulminating preparation of mercury was discovered by Mr. Howard. A hundred grains of mercury are to be dissolved by heat in an ounce and half by measure of nitric acid. This solution being poured cold into two ounces by measure of alcohol in a glass vessel, heat is to be applied, till effervescence is excited. A white vapour undulates on the surface, and a powder is gradually precipitated, which is immediately to be collected on a filter, well washed, and cautiously dried with a very moderate heat. This powder detonates loudly by gentle heat, or slight friction.

The acetic and most other acids combine with the oxide of mercury, and precipitate it from its solution in the nitric acid.

When one part of native sulphuret of antimony is triturated or accurately mixed with two parts of corrosive sublimate, and exposed to distillation; the chlorine combines with the antimony, and rises in the form of the compound called butter of antimony, while the sulphur combines with the mercury, and forms cinnabar. If antimony be used instead of the sulphuret, the residue which rises last consists of running mercury, instead of cinnabar.

Mercury, being habitually fluid, very readily combines with most of the metals, to which it communicates more or less of its fusibility. When these metallic mixtures contain a sufficient quantity of mercury to render them soft at a mean temperature, they are called *amalgams.*

It very readily combines with gold, silver, lead, tin, bismuth, and zinc; more difficultly with copper, arsenic, and antimony; and scarcely at all with platina or iron: it does not unite with nickel, manganese, or cobalt; and its action on tungsten and molybdena is not known. Looking-glasses are covered on the back surface with an amalgam of tin. See SILVERING.

Some of the uses of mercury have already been mentioned in the present article. The amalgamation of the noble metals, water-gilding, the making of vermilion, the silvering of looking-glasses, the making of barometers and thermometers, and the preparation of several powerful medicines, are the principal uses to which this metal is applied.

Scarcely any substance is so liable to adulteration as mercury, owing to the property which it possesses of dissolving completely some of the baser metals. This union is so strong, that they even rise along with the quicksilver when distilled. The impurity of mercury is generally indicated by its dull aspect; by its tarnishing, and becoming covered with a coat of oxide, on long exposure to the air; by its adhesion to the surface of glass; and, when shaken with water in a bottle, by the speedy formation of a black powder. Lead and tin are frequent impurities, and the mercury becomes capable of taking up more of these, if zinc or bismuth be previously added. In order to discover lead, the mercury may be agitated with a little water, in order to oxidize that metal. Pour off the water, and digest the mercury with a little acetic acid. This will dissolve the oxide of lead, which will be indicated by a blackish precipitate with sulphuretted water. Or to this acetic solution add a little sulphate of soda, which will precipitate a sulphate of lead, containing, when dry, 72 per cent of metal. If only a very minute quantity of lead be present in a large quantity of mercury, it may be detected by solution in nitric acid, and the addition of sulphuretted water. A dark brown precipitate will ensue, and will subside if allowed to stand a few days. One part of lead may thus be separated from 15263 parts of mercury. Bismuth is detected by pouring a nitric solution, prepared without heat, into distilled water; a white precipitate will appear if this metal be present. Tin is manifested, in like manner, by a weak solution of nitromuriate of gold, which throws down a purple sediment; and zinc by exposing the metal to heat.

The *black oxide* is rarely adulterated; as it would be difficult to find a substance well suited to this purpose. If well prepared, it may be totally volatilized by heat.

The *red oxide* of mercury by *nitric acid* is very liable to adulteration with red lead. It should be totally volatilized by heat.

Red sulphuret of mercury is frequently adulterated with red lead; which may be detected by heat.

Corrosive muriate of mercury. If there be any reason to suspect arsenic in this salt, the fraud may be discovered as follows: Dissolve a small quantity of the sublimate in distilled water; add a solution of carbonate of ammonia till the precipitation ceases, and filter the solution. If, on the addition of a few drops of ammoniated copper to this solution, a precipitate of a yellowish-green colour be produced, the sublimate contains arsenic.

Sub-muriate of mercury, or calomel, should be completely saturated with mercury. This may be ascertained by boiling, for a few minutes, one part of calomel with a thirty-second part of muriate of ammonia in ten parts of distilled water. When carbonate of potash is added to the filtered solution, no precipitation will ensue, if the calomel be pure. This preparation, when rubbed in an earthen mortar with pure ammonia, should become intensely black, and should exhibit nothing of an orange hue.

* **Mesotype.** Prismatic zeolite. This species of the genus zeolite, is divided by Professor Jameson into three sub-species, the fibrous zeolite, natrolite, and mealy zeolite; which see.*

* **Metals.** The most numerous class of undecompounded chemical bodies, distinguished by the following general characters:—

1. They possess a peculiar lustre, which continues in the streak, and in their smallest fragments.

2. They are fusible by heat; and in fusion retain their lustre and opacity.

3. They are all, except selenium, excellent conductors both of electricity and caloric.

4. Many of them may be extended under the hammer, and are called malleable; or under the rolling press, and are called laminable; or drawn into wire, and are called ductile. This capability of extention, depends in some measure on a tenacity peculiar to the metals, and which exists in the different species with very different degrees of force. See Cohesion.

5. When their saline combinations are electrized, the metals separate at the resino-electric or negative pole.

6. When exposed to the action of oxygen, chlorine, or iodine, at an elevated temperature, they generally take fire, and, combining with one or other of these three elementary dissolvents in definite proportions, are converted into earthy or saline looking bodies, devoid of metallic lustre and ductility, called oxides, chlorides, or iodides.

7. They are capable of combining in their melted state with each other, in almost every proportion, constituting the important order of metallic alloys; in which the characteristic lustre and tenacity are preserved. See Alloy.

8. From this brilliancy and opacity conjointly, they reflect the greater part of the light which falls on their surface, and hence form excellent mirrors.

9. Most of them combine in definite proportions with sulphur and phosphorus, forming bodies frequently of a semi-metallic aspect; and others unite with hydrogen, carbon and boron, giving rise to peculiar gaseous or solid compounds.

10. Many of the metals are capable of assuming, by particular management, crystalline forms; which are, for the most part, either cubes or octohedrons.

The relations of the metals to the various objects of chemistry, are so complex and diversified, as to render their classification a task of peculiar difficulty. I have not seen any arrangement to which important objections may not be offered; nor do I hope to present one which shall be exempt from criticism. The main purposes of a methodical distribution are to facilitate the acquire-ment, retention, and application of knowledge. With regard to metals in general, I conceive these purposes may be to a considerable extent attained, by beginning with those which are most eminently endowed with the characters of the genus, which most distinctly possess the properties that constitute their value in common life, and which caused the early inhabitants of the earth to give to the first metallurgists a place in mythology. Happy had their idolatry been always confined to such real benefactors!

> Inventas aut qui vitam excoluêre per artes;
> Quique sui memores, alios fecêre merendo.

By arranging metals according to the degree in which they possess the obvious qualities of unalterability by common agents, tenacity and lustre, we also conciliate their most important chemical relations, namely, those to oxygen, chlorine and iodine; since their metallic pre-eminence is, popularly speaking, inversely as their affinities for these dissolvents. In a strictly scientific view, their habitudes with oxygen, should perhaps be less regarded in their classification, than with chlorine; for this element has the most energetic attractions for the metals. But, on the other hand, oxygen, which forms one-fifth of the atmospheric volume, and eight-ninths of the aqueous mass, operates to a much greater extent among metallic bodies, and incessantly modifies their form, both in nature and art. Now the order we propose to follow will indicate very nearly their relations to oxygen. As we progressively descend, the influence of that beautiful element progressively increases. Among the bodies near the head, its powers are subjugated by the metallic constitution; but among those near the bottom, it exercises an almost despotic sway, which Volta's magical pile, directed by the genius of Davy, can only suspend for a season. The emancipated metal soon relapses under the dominion of oxygen.

General Table of the Metals.

NAMES.	Sp. Gr.	Precipitants.	Colour of precipitates by			
			Ferroprussiate of potash.	Infus. of galls.	Hydrosulphurets.	Sulphuretted hydrogen.
1 Platinum	21 47	Mur. ammon.	0	0		Black met. pow.
2 Gold	19.30	{ Sulph. iron { Nitr. mercury	Yellowish white	Green; met.	Yellow	Yellow
3 Silver	10.45	Common salt	White	Yel.-brown	Black	Black
4 Palladium	11.8	Prus. mercury	Deep orange		Blackish brown	Black-brown
5 Mercury	13.6	{ Common Salt { Heat	White passing to yellow	Orange-yellow	Brownish-black	Black
6 Copper	8.9	Iron	Red-brown	Brown	Black	Do.
7 Iron	7.7	{ Succin. soda { with perox.	Blue, or white passing to blue	Protox. 0 Perox. black	Black	0
8 Tin	7.29	Corr. sublim.	White	0	{ Protox. black { Perox. yellow	Brown
9 Lead	11.35	Sulph. soda	Do.	White	Black	Black
10 Nickel	8.4	Sulph. potash?	Do.	Gray-white	Do.	0
11 Cadmium	8.6	Zinc	Do.	0	Orange-yellow	Orange-yellow
12 Zinc	6.9	Alk. carbon.	Do.	0	White	Yellowish-white
13 Bismuth	9.88	Water	Do.	Yellow	Black-brown	Black-brown
14 Antimony	6.70	{ Water { Zinc	With dilute solutions white	White from water	Orange	Orange
15 Manganese	8.	Tartr. pot.	White	0	White	Milkiness
16 Cobalt	8.6	Alk. carbon.	Brown-yellow	Yellow-white	Black	0
17 Tellurium	6.115	{ Water { Antimony	0	Yellow	Blackish	
18 Arsenic	{ 8.35? { 5.76?	Nitr. lead	White		Yellow	Yellow
19 Chromium	5.90	Do.	Green	Brown	Green	
20 Molybdenum	8.6	Do.?	Brown	Deep brown		Brown
21 Tungsten	17.4	Mur. lime?	Dilute acids			
22 Columbium	5.6?	Zinc or inf. gal.	Olive	Orange	Chocolate	
23 Selenium	4.3?	{ Iron { Sulphite am.				
24 Osmium	?	Mercury		Purple passing to deep blue		
25 Rhodium	10.65	Zinc?	0		0	
26 Iridium	18.68	Do.?	0	0		
27 Uranium	9.0	Ferropr. pot.	Brown-red	Chocolate	Brown-yellow	0
28 Titanium	?	Inf. galls	Grass-green	Red-brown	Grass-green	0
29 Cerium	?	Oxal. amm.	Milk-white	0	White	0
30 Wodanium	11.47	Zinc	Pearl-gray	0		
31 Potassium	0.865	{ Mur. plat. { Tart. acid	0	0	0	0
32 Sodium	0.972					
33 Lithium						
34 Calcium						
35 Barium						
36 Strontium						
37 Magnesium						
38 Yttrium						
39 Glucinum						
40 Aluminum						
41 Thorinum						
42 Zirconium						
43 Silicium						

The first 12 are malleable; and so are the 31st, 32d, and 33d in their congealed state.

The first 16 yield oxides, which are neutral salifiable bases.

The metals 17, 18, 19, 20, 21, 22, and 23, are acidifiable by combination with oxygen. Of the oxides of the rest, up to the 31st, little is known. The remaining metals form, with oxygen, the alkaline and earthy bases.

The order of their affinity for oxygen, as far as it has been ascertained, is stated in the table of Elective Attraction of oxygen and the metals.

We shall now give an example of the method of analyzing a metallic alloy, of silver, copper, lead, bismuth, and tin.

Let it be dissolved, with the aid of heat, in an excess of nitric acid, sp. gr. 1.23. Evaporate the solution almost to dryness, and pour water on the residuum. We shall thus obtain a solution of the nitrates of silver, copper, and lead, while the oxides of tin and bismuth will be left at the bottom. By exposing the latter mixture, to the action of nitric acid, the oxide of bismuth will be separated from that of tin. To determine the proportions of the other metals, we pour first into the hot and pretty dilute solution, muriatic acid, which will throw down the silver. After filtration, we add sulphate of soda, to separate the lead; and finally, carbonate of potash to precipitate the zinc. The quantity of each metal, may now be deduced from the weight of each precipitate, according to its specific nature, agreeably to the principles of composition, given under the individual metals. See Ores (*Analysis of*).*

*Meteorolites, or Meteoric Stones, are peculiar solid compounds of earthy and metallic matters, of singular aspect and composition, which occasionally descend from the atmosphere, usually from the bosom of a luminous meteor. This phenomenon affords an instructive example of the triumph of human testimony, over philosophical scepticism. The chronicles of almost every age had recorded the fall of ponderous stony or earthy masses from the air; but the evidence had been rejected by historians, forsooth, because the phenomenon was not within the range of *their philosophy*. At length the sober and solid researches of physical science, put to shame the incredulity of the metaphysical school.

"While all Europe," says the celebrated Vauquelin, "resounded with the rumour of stones fallen from the heavens, and while philosophers, distracted in opinion, were framing hypotheses to explain their origin, each according to his own fancy, the Hon. Mr. Howard, an able English chemist, was pursuing in silence the only route which could lead to a solution of the problem. He collected specimens of stones which had fallen at different times, procured as much information as possible respecting them, compared the physical or exterior characters of these bodies; and even did more, in subjecting them to chemical analysis, by means as ingenious as exact.

"It results from his researches, that the stones which fell in England, in Italy, in Germany, in the East Indies, and in other places, have all such a perfect resemblance, that it is almost impossible to distinguish them from each other; and what renders the similitude more perfect and more striking is, that they are composed of the same principles, and nearly in the same proportions."

I have given this just and handsome tribute to English genius in the form of a quotation from the French chemist; by appropriating the language to one's self, as has been practised in a recent compilation, the force of the compliment is in a great measure done away.

"I should have abstained," continues M. Vauquelin, "from any public notice of an object, which has been treated of in so able a manner by the English chemist, if he himself had not induced me to do so, during his residence in Paris; had not the stones which I analyzed been from another country; and had not the interest excited by the subject, rendered this repetition excusable.

"It is therefore to gratify Mr. Howard; to give, if possible, more weight to his experiments; and to enable philosophers to place full confidence in them, rather than to offer any thing new, that I publish this memoir." *Journal des Mines*, No. 76; and *Tilloch's Mag.* vol. xv. p. 346.

It is remarkable, that all the stones. at whatever period, or in whatever part of the world, they may have fallen, have appeared, as far as they have been examined, to consist of the same substances; and to have nothing similar to them, not only among the minerals in the neighbourhood of the places where they were found, but among all that have hitherto been discovered in our earth, as far as men have been able to penetrate. For the chemical analysis of a considerable number of specimens we are particularly indebted to Mr. Howard, as well as to Klaproth and Vauquelin, and a precise mineralogical description of them has been given by the Count de Bournon and others.

They are all covered with a thin crust of a deep black colour; they are without gloss, and their surface is roughened with small asperities. Internally they are grayish, and of a granulated texture, more or less fine. Four different substances are interspersed among their texture, easily distinguished by a lens. The most abundant is from the size of a pin's head to that of a pea, opaque, with a little lustre like that of enamel, of a gray colour sometimes inclined to brown, and hard enough to give faint sparks with steel. Another is a martial pyrites, of a reddish-yellow colour, black when powdered, not very firm in its texture, and not attractible by the magnet. A third consists of small particles of iron in a perfectly metallic state, which give to the mass the quality of being attracted by the magnet, though in some specimens they do not exceed two per cent of the whole weight, while in others they extend to a fourth. These are connected together by a fourth of an earthy consistence in most, so that they may be broken to pieces by the fingers with more or less difficulty. The black crust is hard enough to emit sparks with steel, but may be broken by a stroke with a hammer, and appears to possess the properties of the very attractible black oxide of iron. Their specific gravity varies from 3.352 to 4.281.

The crust appears to contain nickel united with iron, but Mr. Hatchett could not determine its proportion. The pyrites he estimates at iron .68, sulphur .13, nickel .06, extraneous earthy matter .13. In the metallic particles disseminated through the mass, the nickel was in the proportion of one part, or thereabout, to three of iron. The hard separate bodies gave silex .50, magnesia .15, oxide of iron .34, oxide of nickel .025; and the cement, or matrix, silex .48, magnesia .18, oxide of iron .34, oxide of nickel .025. The increase of weight in both these arose from the higher oxidation of the iron. These proportions are taken from the stones that fell at Benares on the 19th of December 1798.

The solitary masses of native iron, that have been found in Siberia, Bohemia, Senegal, and South America, likewise agree in the circumstance of being an alloy of iron and nickel; and are either of a cellular texture, or have earthy matter disseminated among the metal. Hence, a similar origin has been ascribed to them.

Laugier, and afterward Thenard, found chrome likewise, in the proportion of about one per cent, in different meteoric stones they examined.

In all the instances in which these stones have been supposed to fall from the clouds, and of which any perfect account has been given, the appearance of a luminous meteor, exploding with loud noise, has immediately preceded, and hence has been looked to as the cause. The stones likewise have been more or less hot, when found immediately after their supposed fall. Different opinions however have been entertained on this subject, which is certainly involved in much difficulty. Some have supposed them to be merely projected from volcanoes; while others have suggested, that they might be thrown from the moon; or be bodies wandering through space, and at length brought within the sphere of attraction of our planet.

Various lists of the periods, places, and appearances of these showers of stony and earthy matters, have been given from time to time in the scientific Journals. The latest and most complete is that published in the 1st vol. of the Ed. Phil. Journ. compiled partly from a printed list by Chladni, and partly from a manuscript one of Mr. Allan, read some years ago, at the Royal Society of Edinburgh. It appears that Domenico Troili, a Jesuit, published at Modena, in 1766, a work entitled, *Della Caduta di un Sasso dall Aria, ragionamento*, in which the ingenious author proves, in the clearest manner, both from ancient and modern history, that stones had repeatedly fallen from the heavens. This curious dissertation (*ragionamento*) is in the possession of Mr. Allan. The compiler of the new list justly observes, that nothing can show more strikingly the universality and obstinacy of that scepticism, which discredits every thing that it cannot understand, than the circumstance that his work should have produced so little effect, and that the numerous falls of meteoric stones should have so long been ranked among the inventions of ignorant credulity.

Mr. Howard's admirable dissertation was published in the Phil. Trans. for 1802. It is reprinted in the 13th vol. of Tilloch's Magazine, and ought to be studied as a pattern of scientific research. The following Table is copied from the above Journal:—

CHRONOLOGICAL LIST OF METEORIC STONES.

Sect. 1.—*Before the Christian Era.*

Division 1.—Containing those which can be referred pretty nearly to a date.

A. C.

1478. The thunderstone in Crete, mentioned by Malchus, and regarded probably as the symbol of Cybele.—*Chronicle of Paros*, l. 18, 19.

1451. Shower of Stones which destroyed the enemies of Joshua at Beth-horon.—*Joshua*, chap. x. 11.

1200. Stones preserved at Orchomenos.—*Pausanias.*

1168. A mass of iron upon Mount Ida in Crete.—*Chronicle of Paros*, l. 22.

705 or 704. The *Ancyle* or sacred shield, which fell in the reign of Numa. It had nearly the same shape as those which fell at the Cape and at Agram. *Plutarch, in Num.*

654. Stones which fell upon Mount Alba, in the reign of Tullus Hostilius.—"*Crebri cecidere cælo lapides.*"—*Liv.* l. 31.

644. Five stones which fell in China, in the country of Song.—*De Guignes.*

466. A large stone at Ægospotamos, which Anaxagoras supposed to come from the sun. It was as large as a cart, and of a burnt colour.—"*Qui lapis etiam nunc ostenditur, magnitudine vehis, colore adusto.*"—*Plutarch, Pliny*, lib. ii. cap. 58.

465. A stone near Thebes.—*Scholiast of Pindar.*

461. A stone fell in the Marsh of Ancona. —*Valerius Maximus, Liv.* lib. vii. cap. 28.

343. A shower of stones fell near Rome.—*Jul. Obsequens.*

211. Stones fell in China, along with a falling star.—*De Guignes*, &c.

205 or 206. Fiery stones.—*Plutarch, Fab. Max.* cap. 2.

192. Stone fell in China.—*De Guignes.*

176. A stone fell in the Lake of Mars.—"*Lapidem in Agro Crustumino in Lucum Martis de cœlo cecidisse.*"—*Liv.* xli. 3.

90 or 89. "*Eodem causam dicente, lateribus coctis pluisse, in ejus anni acta relatum est.*"—*Plin. Nat. Hist.* lib. ii. cap. 56.

89. Two large stones fell at Yong in China. The sound was heard over 40 leagues. —*De Guignes.*

56 or 52. Spongy iron fell in Lucania.—*Plin.*

46. Stones fell at Acilla.—*Cæsar.*

38. Six stones fell in Leang in China.—*De Guignes.*

29. Four stones fell at Po in China. -*De Guignes.*

22. Eight stones fell from heaven, in China.—*De Guignes.*

12. A stone fell at Ton-Kouan.—*De Guignes.*

9. Two Stones fell in China.—*De Guignes.*

6. Sixteen stones fell in Ning-Tcheon, and other two in the same year.—*De Guignes.*

Division II.—Containing those, of which the date cannot be determined.

The Mother of the Gods which fell at Pessinus.

The stone preserved at Abydos.—*Plin.*

The stone preserved at Cassandria.—*Plin.*

The Black stone, and also another preserved in the Caaba of Mecca.

The "Thunderbolt, black in appearance like a hard rock, brilliant and sparkling," of which the blacksmith forged the sword of Antar.—See *Quarterly Review*, vol. xxi p. 225. and *Antar*, translated by T. Hamilton, Esq. p. 152.

Perhaps the stone preserved in the Coronation Chair of the Kings of England.

Section 2.—After the Christian Era.

P. C.

A stone in the country of the Vocontini.—*Plin.*

452. Three large stones fell in Thrace.—*Cedrenus and Marcellini, Chronicon*, p. 29. —"*Hoc tempore,*" says Marcellinus, "*tres magni lapides e cœlo in Thracia ceciderunt.*"

Sixth Century. Stones fell upon Mount Lebanon, and near Emisa in Syria.—*Damascius.*

About 570. Stones near Bender in Arabia. —*Alkoran*, vi. 16. and cv. 3. and 4.

648. A fiery stone at Constantinople.—*Several Chronicles.*

823. A shower of pebbles in Saxony.

852. A stone fell in Tabaristan, in July or August.—*De Sacy* and *Quatremere.*

897. A stone fell at Ahmedabad.—*Quatremere.* In 892, according to the *Chron. Syr.*

951. A stone fell near Augsburg.—*Alb. Stad.* and others.

998. Two stones fell, one near the Elbe, and the other in the town of Magdeburg. —*Cosmas* and *Spangenberg.*

1009. A mass of iron fell in Djordjan.—*Avicenna.*

1021. Stones fell in Africa between the 24th July and the 21st of August.—*De Sacy.*

1112. Stones or iron fell near Aquileja.—*Valvasor.*

1135 or 1136. A stone fell at Oldisleben, in Thuringia.—*Spangenberg*, and others.

1164. During Pentecost, iron fell in Misnia.—*Fabricius.*

1198. A stone fell near Paris.

1249. Stones fell at Quedlinbourg, Ballenstadt and Blankenburg, on the 26th July. —*Spangenberg* and *Rivander.*

Thirteenth Century. A stone fell at Wurzburg.—*Schottus, Phys. Cur.*

Between 1251 and 1363. Stones fell at Welixoi-Ussing in Russia.—*Gilbert's Annal.* tom. 35.

1280. A stone fell at Alexandria in Egypt. *De Sacy.*

1304, Oct. 1. Stones fell at Friedland or Friedberg.—*Kranz* and *Spangenberg.*

1305. Stones fell in the country of the Vandals.

1328, Jan. 9. In Mortahiah and Dakhaliah. —*Quatremere.*

1368. A mass of iron in the Duchy of Oldenburg.—*Siebrand, Meyer.*

1379, May 26. Stones fell at Minden in Hanover.—*Lerbecius.*

1438. A shower of spongy stones at Roa, near Burgos in Spain.—*Proust.*

—— A stone fell near Lucerne.—*Cysat.*

1491, March 22. A stone fell near Crema. —*Simoneta.*

1492, Nov. 7. A stone of 260 lb. fell at Ensisheim near Sturgau, in Alsace. It is now in the library of Colmar, and has been reduced to 150 lb.—Trithemius, *Hirsaug. Annal. Conrad Gesner, Liber de Rerum Fossilium Figuris*, cap. 3. p. 66. in his *Opera, Zurich*, 1565.

1496, Jan. 26 or 28. Three stones fell between Cesena and Bertonori.—*Buriel* and *Sabellicus.*

1510. About 1200 stones, one of which weighed 120 lb. and others 60 lb. fell in a field near the river Abdua.—"*Color ferrugineus, durities eximia, odor sulphureus.*"—Surius, *Comment.* Cardan, *De rerum Varietate*, lib. xiv. c. 72.

1511, Sept. 4. Several stones, some of which weighed 11 lb. and others 8 lb. fell at Crema.—*Giovanni del Prato*, and others.

1520, May. Stones fell in Arragon.—*Diego de Sayas.*

1540, April 28. A stone fell in the Limousin.—*Bonav. de St. Amable.*

Between 1540 and 1550. A mass of iron fell in the forest of Naunhoff.—*Chronicle of the Mines of Misnia.*

—— Iron fell in Piedmont.—*Mercati* and *Scaliger.*

1548, Nov. 6. A black mass fell at Mansfield in Thuringia.—*Bonav. de St. Amable.*

1552, May 19. Stones fell in Thuringia near Schlossingen.—*Spangenberg.*

1559. Two large stones, as large as a man's head, fell at Miscolz in Hungary, which are said to be preserved in the Treasury at Vienna.—*Sthuansi.*

1561, May 17. A stone called the *Arx Julia*, fell at Torgau and Eilenborg.—*Gesner* and *De Boot.*

1580, May 27. Stones fell near Gottingen.—*Bange.*

1581, July 26. A stone, 39 lb. weight, fell in Thuringia. It was so hot that no person could touch it.—*Binhard, Olearius.*

1583, Jan. 9. Stones fell at Castrovillari.—*Casto, Mercati* and *Imperati.*

1583, in the Ides of Jan. A stone of 30 lb. resembling iron, fell at Rosa in Lavadie.

—— March 2. A stone fell in Piedmont of the size of a grenade.

1591, June 19. Some large stones fell at Kunersdorf.—*Lucas.*

1596, March 1. Stones fell at Crevalcose.—*Mittarelli.*

In the *Sixteenth Century*, not in 1603. A stone fell in the kingdom of Valencia.—*Casius* and the *Jesuits of Coimbra.*

1618, August. A great fall of stones took place in Styria.—*Stammes.*

—— A metallic mass fell in Bohemia.—*Kronland.*

1621, April 17. A mass of iron fell about 100 miles S. E. of Lahore.—*Jehan Guir's Memoirs.*

1622, Jan. 10. A stone fell in Devonshire.—*Rumph.*

1628, April 9. Stones fell near Hatford in Berkshire; one of them weighed 24 lb.—*Gent. Mag.* Dec. 1796.

1634, Oct. 27. Stones fell in Charollois.—*Morinus.*

1635, June 21. A stone fell at Vago in Italy.

—— July 7, or Sept. 29. A stone, weighing about 11 oz. fell at Calce.—*Valisnieri,* Opere, vi. 64.

1636, March 6. A burnt looking stone fell between Sagan and Dubrow in Silesia.—*Lucas* and *Cluverius.*

1637, Nov. 29. Gassendi says, a stone of a black metallic colour, fell on Mount Vaision, between Guilliaume and Perne in Provence. It weighed 54 lb. and had the size and shape of the human head. Its specific gravity was 3.5.—*Gussendi, Opera*, p. 96. Lyons, 1658.

1642, August 4. A stone weighing 4 lb. fell between Woodbridge and Aldborough in Suffolk.—*Gent. Mag.* Dec. 1796.

1643, or 1644. Stones fell in the sea.—*Wuofbrain.*

1647, Feb. 18. A stone fell near Fwicxau.—*Schmid.*

—— August. Stones fell in the bailliage of Stolzenem in Westphalia.—*Gilbert's Annal.*

Between 1647 and 1654. A mass fell in the sea.—*Willman.*

1650, August 6. A stone fell at Dordrecht.—*Senguesd.*

1654, March 30. Stones fell in the Island of Funen.—*Bartholinus.*

A large stone fell at Warsaw.—*Petr. Borellus.*

A small stone fell at Milan, and killed a Franciscan.—*Museum Septalianum.*

1668, June 19. or 21. Two stones, one 300 lb. and the other 200 lb. weight, fell near Verona. Legallois, *Conversations*, &c. Paris 1672, Valisnieri, *Opere*, ii. p. 64. 66. *Montanan* and *Francisco Carli*, who published a letter containing several curious notices respecting the fall of stones from the heavens.

1671, Feb. 27. Stones fell in Suabia.—*Gilbert's Annal.* tom. xxxiii.

1673. A stone fell in the fields near Dietling.—"*Nostris temporibus in partibus Galliæ Cispadanæ, lapis magnæ quantitatis e nubibus cecidit.*"—See Leonardus, *de Gemmis*, lib. i. cap. 5.; and *Memorie della Societa Colombaria Fiorentina*, 1747, vol. i. diss. vi. p. 14.

1674, Oct. 6. Two large stones fell near Glaris.—*Scheuchzer.*

Between 1675 and 1677. A stone fell into a fishing-boat near Copinshaw.—Wallace's *Account of Orkney*, and *Gent. Mag.* July 1806.

1677, May 28. Several stones, which probably contained copper, fell at Ermundorf near Roosenhaven.—Misi, *Nat. Cur.* 1677. App.

1680, May 18. Stones fell at London.—*King.*

1697, Jan. 13. Stones fell at Pentolina near Sienna.—*Soldani* after *Gabrieli.*

1698, May 19. A stone fell at Walhing.—*Scheuchzer.*

1706, June 7. A stone of 72 lb. fell at Larissa in Macedonia. It smelled of sulphur, and was like the scum of iron.—*Paul Lucas.*

1722, June 5. Stones fell near Scheftlas in Freisingen.—*Meichelbeck.*

1723, June 22. About 33 stones, black and metallic, fell near Plestowitz in Bohemia. —*Rost* and *Stepling*.

1727, July 22. Stones fell at Lilaschitz in Bohemia.—*Stepling*

1738, August 18. Stones fell near Carpentras.—*Castillon*.

1740, Oct. 25. Stones fell at Rasgrad.—*Gilbert's Annal.* tom. 1.

—— to 1741. A large stone fell in winter in Greenland. —*Egede*.

1743. Stones fell at Liboschitz in Bohemia. —*Stepling*.

1750, Oct. 1. A large stone fell at Niort near Coutance.—*Huard* and *Lalande*.

1751, May 26. Two masses of iron of 71 lb. and 16 lb. fell in the district of Agram, the capital of Croatia. The largest of these is now in Vienna.

1753, Jan. A stone fell in Germany, in Eichstadt.—*Cavallo*, iv. 377.

—— July 3. Four stones, one of which weighed 13 lb. fell at Strkow, near Tabor. —*Stepling*, "*De Pluvia lapidea, anni 1753, ad Strkow, et ejus causis, meditatio*," p. 4.—Prag. 1754.

—— Sept. Two stones, one of 20 lb. and the other of 11 lb. fell near the villages of Liponas and Pin in Brene.—*Lalande* and *Richard*.

1755, July. A stone fell in Calabria, at Terranuova, which weighed 7 lb. 7½ oz. —*Domin. Tata*.

1766, end of July. A stone fell at Albereto in Modena.—*Troili*.

—— August 15. A stone fell at Novellara. —*Troili*.

1768, Sept. 13. A stone fell near Luce in Maine. It was analyzed by Lavoisier, &c. —*Mem. Acad. Par.*

—— A stone fell at Aire.—*Mem. Acad. Par.*

1768, Nov. 20. A stone, weighing 38 lb. fell at Mauerkirchen in Bavaria.—*Imhof*.

1773, Nov. 17. A stone, weighing 9 lb. 1 oz. fell at Sena in Arragon.—*Proust*.

1775, Sept. 19. Stones fell near Rodach in Cobourg.—*Gilbert's Annal.* tom. xxiii.

—— or 1776. Stones fell at Obruteza in Volhynia.—*Gilbert's Annal.* tom. xxxi.

1776 or 1777, Jan. or Feb. Stones fell near Fabriano.—*Soldani* and *Amoretti*.

1779. Two stones, weighing 3½ oz. each, fell at Pettiswoode in Ireland.—*Bingley*, in *Gent. Mag.* Sept. 1796.

1780, April 1. Stones fell near Beeston in England.—*Evening Post*.

1782. A stone fell near Turin.—*Tata* and *Amoretti*.

1785, Feb. 19. Stones fell at Eichstadt.—*Pickel* and *Stalz*.

1787, Oct. 1. Stones fell in the province of Charkow in Russia.—*Gilbert's Annal.* tom. xxxi.

1790, July 24. A great shower of stones fell at Barbotan near Roquefort, in the vicinity of Bordeaux. A mass, 15 inches in diameter, penetrated a hut, and killed a herdsman and a bullock. Some of the stones weighed 25 lb. and others 30 lb.—*Lomet*.

1791, May 17. Stones fell at Cassel-Berardenga, in Tuscany.—*Soldani*.

1794, June 16. Twelve stones, one of which weighed 7¼ oz. fell at Sienna. Howard and Klaproth have analyzed these stones. —*Phil. Trans.* 1794, p. 103.

1795, April 13. Stones fell at Ceylon.—*Beck*.

—— Dec. 13. A large stone, weighing 55 lb. fell near Wold Cottage in Yorkshire. No light accompanied the fall.—*Gent. Mag.* 1796.

1796, Jan. 4. Stones fell near Belaja-Ferk'wa in Russia.—*Gilbert's Annal.* tom xxxv.

—— Feb. 19. A stone of 10 lb. fell in Portugal.—Southey's *Letters from Spain*.

1798, March 8. or 12. Stones, one of which was the size of a calf's head, fell at Sales. —*Marquis de Dree*.

—— Dec. 19. Stones fell in Bengal.—*Howard*, *Lord Valentia*.

1799, April 5. Stones fell at Batonrouge on the Mississippi.—*Belfast Chronicle of the War*.

1801. Stones fell on the Island of Tonneliers.—*Bory de St. Vincent*.

1802, Sept. Stones fell in Scotland? *Monthly Magazine*, Oct. 1802.

1803, April 26. A great fall of stones took place at Aigle. They were about three thousand in number, and the largest weighed about 17 lb.

—— Oct. 5. Stones fell near Avignon.—*Bibl. Brit.*

—— Dec. 13. A stone fell near Eggenfelde in Bavaria, weighing 3½ lb.—*Imhof*.

1804, April 5. A stone fell at Possil, near Glasgow.

—— — 1807. A stone fell at Dordrecht.—*Van Beek. Culkoen*.

1805, March 25. Stones fell at Doronins in Siberia.—*Gilbert's Annal.* tom. xxix. and xxxi.

—— June. Stones, covered with a black crust, fell in Constantinople.

1806, March 15. Two stones fell at St. Etienne and Valence; one of them weighed 8 lb.

—— May 17. A stone weighing 2½ lb. fell near Basingstoke in Hampshire.—*Monthly Magazine*.

1807, March 13. (June 17, according to Lucas). A stone of 160 lb. fell at Fimochin, in the province of Smolensko in Russia.—*Gilbert's Annal.*

—— Dec. 14. A great shower of stones fell near Weston in Connecticut. Masses of 20 lb. 25 lb. and 35 lb. were found.—*Silliman* and *Kingsley*.

1808, April 19. Stones fell at Borgo San-Donino.—*Cuidotti* and *Spagnoni*.

—— May 22. Stones weighing 4 lb. or 5 lb. fell near Stannern in Moravia.—*Bibl. Brit.*

1808, Sept. 3. Stones fell at Lissa in Bohemia.—*De Schreibers.*

1809, June 17. A stone of 6 oz. fell on board an American vessel, in latitude 30° 58′ N., and longitude 70° 25′ W.—*Bibl. Brit.*

1810, Jan. 30. Stones, some of which weighed about 2 lb. fell in Caswell county, North America.—*Phil. Mag.* vol. xxxvi.

—— July. A great stone fell at Shahabad in India. It burned five villages, and killed several men and women.—*Phil. Mag.* xxxvii. p. 236.

—— Aug. 10. A stone weighing 7¾ lb. fell in the county of Tipperary in Ireland. —*Phil. Mag.* vol. xxxviii.

—— Nov. 23. Stones fell at Mortelle, Villerai, and Moulinbrulé, in the department of the Loiret; one of them weighed 40 lb. and the other 20 lb.—*Nich. Journal,* vol. xxxix. p. 158.

1811, March 12 or 13. A stone of 15 lb. fell in the village of Konglinhowsh, near Romea in Russia.—Bruce's *American Journal,* No. 3.

1811, July 8. Stones, one of which weighed 3¼ oz. fell near Balanguillas in Spain.—*Bibl. Brit.* tom. xlviii. p. 162.

1812, April 10. A shower of stones fell near Thoulouse.

—— April 15. A stone, the size of a child's head, fell at Erxleben. A specimen of it is in the possession of Professor Haussman of Brunswick.—*Gilbert's Annal.* xl. and xli.

—— Aug. 5. Stones fell at Chantonay.—*Brochant.*

1813, March 14. Stones fell at Cutro in Calabria, during a great fall of red dust. —*Bibl. Brit.* Oct. 1813.

—— Sept. 9. and 10. Several stones, one of which weighed 17 lb. fell near Limerick in Ireland.—*Phil. Mag.*

1814, Feb. 3. A stone fell near Bacharut in Russia.—*Gilbert's Annal.* tom. 1.

—— Sept. 5. Stones, some of which weighed 18 lb. fell in the vicinity of Agen.—*Phil. Mag.* vol. xlv.

—— Nov. 5. Stones, of which 19 were found, fell in the Doab in India.—*Phil. Mag.*

1815, Oct. 3. A large stone fell at Chassigny near Langres.—*Pistollet.*

1816. A stone fell at Glastonbury in Somersetshire.—*Phil. Mag.*

1817, May 2. and 3. There is reason to think, that masses of stone fell in the Baltic after the great meteor of Gottenburg.—*Chladni.*

1818, Feb. 15. A great stone appears to have fallen at Limoge, but it has not been disinterred.—*Gazette de France,* Feb. 25, 1818.

—— July 29. O. S. A stone of 7 lb. fell at the village of Slobodka in Smolensko. It penetrated nearly 16 inches into the ground. It had a brown crust with metallic spots.

LIST OF MASSES OF IRON SUPPOSED TO HAVE FALLEN FROM THE HEAVENS.

Sect 1.—*Spongy or Cellular Masses containing Nickel.*

1. The mass found by Pallas in Siberia, to which the Tartars ascribe a meteoric origin.—*Voyages de Pallas,* tom. iv. p. 545. *Paris* 1793.
2. A fragment found between Eibenstock and Johanngeorgenstadt.
3. A fragment probably from Norway, and in the imperial cabinet of Vienna.
4. A small mass weighing some pounds, and now at Gotha.
5. Two mass in Greenland, out of which the knives of the Esquimaux were made. —See Ross's *Account of an Expedition to the Arctic Regions.*

Sect. 2.—*Solid Masses where the Iron exists in Rhomboids or Octohedrons, composed of Strata, and containing Nickel.*

1. The only fall of iron of this kind, is that which took place at Agram, in 1751.
2. A mass of the same kind has been found on the right bank of the Senegal.—*Compagnon, Forster, Goldberry.*
3. At the Cape of Good Hope; Stromeyer has lately detected cobalt in this mass. —*Van Marum* and *Dankelman; Brande's Journal,* vol. vi. 162.
4. In different parts of Mexico.—*Sonneschmidt, Humboldt,* and the *Gazette de Mexico,* tom. i. and v.
5. In the province of Bahia in Brazil. It is seven feet long, four feet wide, and two feet thick, and its weight about 14,000 lb. —*Mornay* and *Wollaston; Phil. Trans.* 1816, p. 270..281.
6. In the jurisdiction of San Jago del Estera.—*Rubin de Celis,* in the *Phil. Trans.* 1788, vol. lxxviii. p. 37.
7. At Elbogen in Bohemia.—*Gilbert's Annal.* xlii. and xliv.
8. Near Lenarto in Hungary.—*Ditto,* xlix.

The origin of the following masses seems to be uncertain, as they do not contain nickel, and have a different texture from the preceding:—

1. A mass found near the Red River, and sent from New Orleans to New York.—*Journ. des Mines* 1812, *Bruce's Journ.*
2. A mass at Aix-la-Chapelle, containing arsenic.—*Gilbert's Annal.* xlviii.
3. A mass found on the hill of Brianza in the Milanese.—Chladni, in *Gilbert's Annal.* 1. p. 275.
4. A mass found at Groskamdorf, and containing, according to Klaproth, a little lead and copper.

Nickel or chromium is found to be the constant associate of the iron in the meteorolites. It is characteristic of meteoric iron, as it is never found in mineral native iron.

Nickel has been hitherto regarded as the sole characteristic ingredient of meteoric stones, but from the analysis of some late meteorolites, it would appear, that this metal is occasionally absent, while chromium is always found. Hence the latter has come to be viewed as the constant characteristic.

The phenomenon of red snow observed at Baffin's Bay, has of late excited some speculation, being supposed to be a meteoric phenomenon. But Mr. Bauer has proved by microscopic examination, that the colouring particles consist of a new species of the *uredo*, which grows upon the snow, to which he has given the appropriate name of *uredo nivalis*. He found the real diameter of an individual full grown globule of this fungus, to be the *one thousand six hundredth part of an inch*. Hence, in order to cover a single square inch, two million five hundred and sixty thousand of them are necessary. *Journal of Science, vol. vii, p.* 222.*

* **Meteorology.** See Climate, Dew, Rain.*

* **Miasmata.** Vapours or effluvia, which by their application to the human system, are capable of exciting various diseases, of which the principal are intermittent, remittent, and yellow fevers, dysentery and typhus. That of the last is generated in the human body itself, and is sometimes called the typhoid fomes. The other miasmata are produced from moist vegetable matter, in some unknown state of decomposition. The contagious *virus* of the plague, small-pox, measles, chincough, cynanche maligna, and scarlet fever, as well as of typhus and the jail fever, operates to a much more limited distance through the intermedium of the atmosphere, than the marsh miasmata. Contact of a diseased person is said to be necessary for the communication of plague; and approach within 2 or 3 yards of him, for that of typhus. The Walcheren miasmata extended their pestilential influence to vessels riding at anchor, fully a quarter of a mile from the shore.

The chemical nature of all these poisonous effluvia is little understood. They undoubtedly consist, however, of hydrogen, united with sulphur, phosphorus, carbon, and azote, in unknown proportions, and unknown states of combination. The proper neutralizers or destroyers of these gasiform poisons, are nitric acid vapour, muriatic acid gas, and chlorine. The last two are the most efficacious; but require to be used in situations from which the patients can be removed at the time of the application. Nitric acid vapour may, however, be diffused in the apartments of the sick, without much inconvenience. Bed-clothes, particularly blankets, can retain the contagious fomes, in an active state, for almost any length of time. Hence, they ought to be fumigated, with peculiar care. The vapour of burning sulphur or sulphurous acid is used in the East against the plague. It is much inferior in power to the other antiloimic reagents.*

* **Mica.** Professor Jameson subdivides this mineral species into ten sub-species; viz. mica, pinite, lepidolite, chlorite, green earth, talc, nacrite, potstone, steatite, and figure-stone.

Mica. Colours, yellowish and greenish-gray. Massive, disseminated, and crystallized. Its primitive figure is a rhomboid. The secondary forms are; an equiangular six-sided prism, or table; a rectangular four-sided prism, or table; and a six-sided pyramid. Lateral planes smooth and splendent; terminal, longitudinally streaked. Lustre pearly, or semi-metallic. Cleavage single. Fragments tabular and splintery. Translucent. Sectile. Streak gray-coloured. Harder than gypsum, but not so hard as calcareous spar. Feels meagre or smooth. Elastic-flexible. Sp. gr. 2.65. Before the blow-pipe it melts into a grayish-white enamel. Its constituents are, silica 47, alumina 22, oxide of iron 15.5, oxide of manganese 1.75, potash 14.5.—*Klaproth.* It occurs along with feldspar and quartz in feldspar and gneiss. It sometimes forms short beds, in granite and other primitive rocks. Most of the mica of commerce is brought from Siberia, where it is used for window-glass.*

Microcosmic Salt. A triple salt of soda, ammonia, and phosphoric acid, obtained from urine, and much used in assays by the blow-pipe.

* **Miemite**; of which there are two kinds, the granular and prismatic, both sub-species of dolomite.

Granular miemite. Colour pale asparagus-green. Massive, in granular distinct concretions, and crystallized in flat double three-sided pyramids. Lustre splendent, pearly. Cleavage threefold oblique angular. Translucent. Semi-hard. Brittle. Sp. gr. 2.885. It dissolves slowly, and with little effervescence, in cold nitric acid. Its constituents are, carbonate of lime 53, carbonate of magnesia 42.5, carbonate of iron, with a little manganese, 3.0. It is found at Miemo in Tuscany, imbedded in gypsum, at Hall in the Tyrol, and in Greenland.

Prismatic miemite. Colour asparagus-green. It occurs in prismatic distinct concretions, and crystallized in flat rhomboids, which are deeply truncated on all their edges. Internally shining. Fracture passes from concealed foliated to splintery. Strongly translucent. As hard as the former. Sp. gr. 2.885. It dissolves like the other. Its constituents are, lime 33, magnesia 14.5, oxide of iron 2.5, carbonic acid 47.25. water and loss 2.75.—*Klapr.* It occurs in cobalt veins that traverse sandstone, at Glücksbrunn in Gotha.

Milk is a well known fluid, secreted in peculiar vessels of the females of the human species, of quadrupeds, and of cetaceous animals, and destined for the purpose of nourishing their young.

When milk is left to spontaneous decomposition, at a due temperature, it is found to be capable of passing through the vinous, acetous, and putrefactive fermentations. It appears, however, probable on account of the small quantity of alcohol it affords, that the vinous fermentation lasts a very short time, and can scarcely be made to take place in every part of the fluid at once by the addition of any ferment. This seems to be the reason, why the Tartars, who make a permanent liquor, or wine, from mare's milk, called *koumiss*, succeed by using large quantities at a time, and agitating it very frequently. They add as a ferment a sixth part of water, and an eighth part of the sourest cow's milk they can get, or a smaller portion of koumiss already prepared; cover the vessel with a thick cloth, and let it stand in a moderate warmth for 24 hours; then beat it with a stick, to mix the thicker and thinner parts, which have separated; let it stand again 24 hours in a high narrow vessel, and repeat the beating, till the liquor is perfectly homogeneous. This liquor will keep some months, in close vessels, and a cold place; but must be well mixed by beating or shaking every time it is used. They sometimes extract a spirit from it by distillation. The Arabs prepare a similar liquor by the name of *leban*, and the Turks by that of *yaourt*. Eton informs us, that, when properly prepared, it may be left to stand till it becomes quite dry; and in this state it is kept in bags, and mixed with water when wanted for use.

The saccharine substance, upon which the fermenting property of milk depends, is held in solution by the whey, which remains after the separation of the curd in making cheese. This is separated by evaporation in the large way, for pharmaceutical purposes, in various parts of Switzerland. When the whey has been evaporated by heat, to the consistence of honey, it is poured into proper moulds, and exposed to dry in the sun. If this crude sugar of milk be dissolved in water, clarified with whites of eggs, and evaporated to the consistence of sirup, white crystals, in the form of rhomboidal parallelopipedons, are obtained.

Sugar of milk has a faint saccharine taste, and is soluble in three or four parts of water. It yields by distillation the same products that other sugars do, only in somewhat different proportions. It is remarkable, however, that the empyreumatic oil has a smell resembling flowers of benzoin. It contains an acid frequently called the saccholactic; but as it is common to all mucilaginous substances, it has been termed mucic. See Acid (Mucic).

The kinds of milk that have been chemically examined, are mare's, woman's, ass's, goat's, sheep's, and cow's. We have here placed them according to the proportion of *sugar* they afforded; and this, Parmentier observes, was precisely of the same quality in all, while all the other parts varied in quality as well as quantity in the different milks. With regard to the *whey*, they rank in the following order; ass's, mare's, woman's, cow's, goat's, sheep's: to *cream;* sheep's, woman's, goat's, cow's, ass's, mare's: to *butter;* sheep's, goat's, cow's, woman's: to *cheese;* sheep's, goat's, cow's, ass's, woman's, mare's. Parmentier could not make any butter from the cream of woman's, ass's, or mare's milk; and that from sheep he found always remained soft. From their general properties, he has divided them into two classes; one abounding in serous and saline parts, which includes ass's, mare's, and woman's; the other rich in caseous and butyraceous parts, which are cow's, goat's, and sheep's.

* Cream, sp. gr. 1.0244 by Berzelius's analysis, consists of butter 4.5, cheese 3.5, whey 92. Curd, by the analysis of MM. Gay-Lussac and Thenard, is composed of

Carbon,	59.781
Oxygen,	11.400
Hydrogen,	7.429
Azote,	21.381
	100.000

Whey always reddens vegetable blues, from the presence of lactic acid. Milk, according to Berzelius, consists of,

Water, - - - - -	928.75
Curd, with a little cream,	28.00
Sugar of milk, - -	35.00
Muriate of potash, - -	1.70
Phosphate of potash, -	0.25
Lactic acid, acetate of potash, with a trace of lactate of iron, - - - -	6.00
Earthy phosphates, - -	0.30
	1000.00

Since both cream and water affect the specific gravity of milk alike, it is not possible to infer the quality of milk from the indications merely of a specific gravity instrument. We must first use as a lactometer, a graduated glass tube, in which we note the thickness of the stratum of cream afforded, after a proper interval, from a determinate column of new milk. We then apply to the skimmed milk, a hydrometric instrument, from which we learn the relative proportions of curd and whey. Thus, the combination of the two instruments furnishes a tolerably exact lactometer.*

* Milk-quartz. See Quartz*.

* **MINERALOGY.** That department of natural history which teaches us to describe, recognize, and classify, the different genera and species of the objects of inorganic nature. As the greater part of these are solids, extracted from the earth by mining, they are called MINERALS. The term FOSSIL is now commonly restricted to such forms of organic bodies, as have been penetrated with earthy or metallic matters.

Professor Mohs of Freyberg, has lately published a work, replete with profound general views on mineralogy, which promises to place the science on a surer basis than it has hitherto stood.

Werner first taught mineralogists to consider the productions of inorganic nature in a state of mutual connexion, resulting from mineralogical similarity. Thus, heavy spar is plainly more similar to calcareous spar, than feldspar is; feldspar than garnet; garnet than iron-glance; iron-glance than native gold; and so on.

A collection of species connected by the *highest*, and at the same time, equal degrees of natural-history similarity, is named a *genus*. The same occurs in zoology and botany. Thus, the wolf, dog, fox; the lion, tiger, cat, unite into genera. Individuals whose forms belong to two different systems of crystallizations, cannot be united in the same species. Radiated hepatic, and cristated iron pyrites, therefore, constitute a distinct species. Yet this species is so similar to that of common iron pyrites (tessular), that we must unite them into one genus.

An order comprehends several analogous genera; and a class, analogous orders.

The specific character consists particularly of three characters. These are the crystalline forms, (including cleavage), the degrees of hardness, and the specific gravity. The crystalline forms may be reduced in all cases to one of *four* SYSTEMS OF CRYSTALLIZATION; the RHOMBOHEDRAL: the PYRAMIDAL, derived from a four-sided isosceles pyramid; the PRISMATIC, derived from a scalene four-sided pyramid; and lastly the TESSULAR, or that which is derived from the hexahedron.

When we wish to determine the species to which any mineral belongs; by means of a tabular view, we must first ascertain either its primitive form or cleavage, and afterwards the hardness and specific gravity. The degrees of hardness are expressed by Mohs in the following manner:

1 expresses the hardness of Talc,
2 Gypsum,
3 Calcareous spar,
4 Fluor spar,
5 Apatite,
6 Feldspar,
7 Quartz,
8 Topaz,
9 expresses the hardness of Corundum,
10 Diamond.

Professor Mohs has arranged minerals in to three classes.

I. Character of the first class.

If solid; sapid. No bituminous odour Sp. gr. under 3.8. It has 4 orders.

Order 1. *Gas.* Expansible. Not acid.

2. *Water.* Liquid. Without odour or sapidity. Sp. gr. 1.

3. *Acid.* Acid. Specific gravity, 0.0015 to 3.7.

4. *Salt.* Not acid. Sp. gr. 1.2 to 2.9.

II. Character of the second class.

Insipid. Sp. gr. above 1.8.

Order 1. *Haloide* (salt-like). Not metallic. Streak uncoloured.

If pyramidal or prismatic; H. hardness = 4 and less. If tessular, H. = 4.0. If single, perfect, and eminent faces of cleavage; sp. gr. = 2.4 and less.

H. = 1.5 to 5.0. If under 2.5, sp. gr. = 2.4 and less. Sp. gr = 2.2 to 3.3. If 2.4 and less; H. under 2.5; and no resinous lustre.

Order 2. *Baryte.*

Not metallic. If adamantine or imperfect metallic lustre; sp. gr. = 6.0, and more. Streak uncoloured, or orange-yellow. If orange-yellow; sp. gr. = 6.0 and more, and H. = 3.0 and less.

H. = 2.5 to 5.0. If 5.0; sp. gr. under 4.5.

Sp. gr. = 3.3 to 7.2. If under 4 0 and H. = 5.0; cleavage dis-prismatic.

Order 3. *Kerate* (Horny).

Not metallic. Streak uncoloured. No single eminent cleavage. H. = 1.0 to 2.0. Sp. gr. = 5.5.

Order 4. *Malachite.*

Not metallic. Colour blue, green, brown. If brown, colour of streak: H. = 3.0 and less; and sp. gr. above 2.5. If uncoloured streak; sp. gr. = 2.2 and less; and H. = 3.0. No single eminent faces of cleavage. H. = 2.0 to 5.0. Sp, gr. = 2.0 to 4.6.

Order 5. *Mica.*

If metallic: Sp. gr. under 2.2. If not metallic: Sp. gr. above 2.2. If yellow streak; pyramidal. Single eminent cleavage. H. = 1.0 to 4.5. If above 2.5; rhombohedral. Sp. gr. = 1.8 to 5.6. If under 2.5; metallic. If above 4.4; streak uncoloured.

Order 6. *Spar.*

Not metallic. Streak uncoloured, brown. If rhombohedral; sp. gr. 2.2 and less, or H. = 6.0.

H. = 3.5 to 7. If 4.0 and less; single eminent cleavage. If above 6.0; sp. gr. under 2.5, or above 2.8; and pearly lustre. Sp. gr. = 2.0 to 3.7. If above 3.3; hemi-prismatic, or H. = 6.0; and no adamantine lustre. If 2.4 and less; not without traces of form and cleavage.

Order 7. *Gem.*

Not metallic. Streak uncoloured. H.

= 5.5 to 10. If 6.0 and less; sp. gr. = 2.4 and less; and no traces of form and cleavage. Sp. gr. 1.9 to 4.7. If under 3.8; no pearly lustre.

Order 8. *Ore.*

If metallic; black. If not metallic; adamantine, or imperfect metallic lustre. If yellow or red streak; H. = 3.5 and more; and sp. gr. = 4.8 and more. If brown or black streak; H. = 5.0 and more, or perfectly prismatoidal. H. = 2.5 to 7.0. If 4.5 and less; red, yellow, or black streak. If 6.5 and more, and streak uncoloured; sp. gr. = 6.5 and more. Sp. gr. = 3.4 to 7.4.

Order 9. *Metal.*

Metallic. Not black. If gray; malleable; and sp. gr. = 7.4 and more. H. = 0.0 to 4.0 or malleable. Sp. gr. = 5.7 to 20.0.

Order 10. *Pyrites.*

Metallic. H. = 3 5 to 6.5. If 4.5 and less; sp. gr. under 5.0 Sp. gr. = 4.1 to 7.7. If 5.3 and less; colour yellow or red.

Order 11. *Glance.*

Metallic. Gray, black. H. 1.0 to to 4.0. Sp. gr. = 4.0 to 7.6. If under 5.0, and single perfect cleavage; lead-gray. If above 7.4; lead-gray.

Order 12. *Blende.*

If metallic; black. If not metallic; adamantine lustre. If brown streak; uncoloured. Sp. gr. between 4.0 and 4.2; and the form tessular. If red streak; sp. gr. = 4.5 and more; and H. = 2.5 and less.

H. = 1.0, 4.0. Sp. gr. = 3.9, 8.2. If 4.3 and more; streak red.

Order 13. *Sulphur.*

Not metallic. Colour red, yellow, or brown. Prismatic. H. = 1.0 to 2.5. Sp. gr. = 1.9 to 3.6. If above 2.1; streak yellow, or red.

CLASS III.

If fluid; bituminous odour. If solid; insipid. Sp. gr. under 1.8.

Order 1. *Resin.*

Fluid, solid. Streak uncoloured, yellow, brown, black. H. = 0.0 to 2.5. Sp. gr. = 0.7 to 1.6. If 1.2 and more; streak uncoloured.

Order 2. *Coal.*

Solid. Streak, brown, black. H. = 0.1 to 2.5. Sp. gr. = 1.2 to 1.5.

GENERA.

CLASS I. Order 1. *Gas.*

Genera. 1. Hydrogen. 2. Atmospheric air.

Order 2. *Water.*

Genus. 1. Atmospheric water.

Order 3. *Acid.*

Genera. 1. Carbonic. 2. Muriatic. 3. Sulphuric. 4. Boracic; and 5. Arsenic.

Order 4. *Salt.*

Genera. 1. Natron-salt. 2. Glauber-salt. 3, Nitre-salt. 4. Rock-salt. 5. Ammoniac-salt. 6. Vitriol-salt; comprising as species, the sulphates of iron, copper and zinc. 7. Epsom-salt. 8. Alum-salt. 9. Borax-salt. 10. Brythine-salt (heavy-salt). Glauberite.

CLASS II. Order 1. *Haloide.*

Genera. 1 Gypsum-haloide. 2. Cryone-haloide. 3. Alum-haloide. 4. Fluor-haloide. 5. Calc-haloide.

Order 2. *Baryte.*

Genera. 1. Parachrose-baryte (altered colour). 2. Zinc-baryte. 3. Scheelium-baryte. 4. Hal-baryte. 5. Lead-baryte.

Order 3. *Kerate.*

Genera. 1. Pearl-kerate.

Order 4. *Malachite.*

Genera. 1. Staphyline-malachite (grape like). 2. Lirocone-malachite (form unknown). 3. Olive-malachite. 4. Azure-malachite. 5. Emerald-malachite. 6. Habroneme-malachite (fine threaded).

Order 5. *Mica.*

Genera. 1. Euchlore-mica (bright-green). 2. Antimony-mica. 3. Cobalt-mica. 4. Iron-mica. 5. Graphite mica. 6. Talc-mica. 7. Pearl-mica.

Order 6. *Spar.*

Genera. 1. Schiller-spar. 2. Disthene-spar. 3. Triphane-spar. 4. Dystome-spar (difficult to cleave). 5. Kouphone-spar (light). 6. Petaline-spar. 7. Feldspar. 8. Augite-spar. 9. Azure-spar.

Order 7. *Gem.*

Genera. 1. Andalusite. 2. Corundum. 3. Diamond. 4. Topaz. 5. Emerald. 6. Quartz: 7. Axinite. 8. Chrysolite. 9. Boracite. 10. Tourmaline. 11, Garnet. 12. Zircon. 13. Gadolinite.

Order 8. *Ore.*

Genera. 1. Titanium-ore. 2. Zinc-ore. 3. Copper-ore. 4. Tin-ore. 5. Scheelium-ore. 6. Tantalum-ore. 7. Uranium-ore. 8. Cerium-ore. 9. Chrome-ore. 10. Iron-ore. 11. Manganese-ore.

Order 9. *Metal.*

Genera. 1. Arsenic. 2. Tellurium. 3. Antimony. 4. Bismuth. 5. Mercury. 6. Silver. 7. Gold. 8. Platina. 9. Iron. 10. Copper.

Order 10. *Pyrites.*

Genera. 1. Nickel-pyrites. 2. Arsenic-pyrites. 3. Cobalt-pyrites. 4. Iron-pyrites. 5. Copper-pyrites.

Order 11. *Glance,*

Genera. 1. Copper-glance. 2. Silver-glance. 3. Lead-glance. 4. Tellurium-glance. 5. Molybdena-glance. 6. Bismuth-glance. 7. Antimony-glance. 8. Melane-glance (black).

Order 12. *Blende.*

Genera. 1. Glance-blende. 2. Garnet-blende. 3. Purple-blende. 4. Ruby-blende.

Order 13. *Sulphur.*

1. Sulphur.

CLASS III. Order 1. *Resin.*

Genus. Melichrone-resin (honey-coloured).

Order 2. *Coal.*

Genus. Mineral-coal.

Such are the Genera of Professor Mohs. I would willingly have introduced a view of the species; but his symbols of their crystalline structure and forms would require a detailed explanation, inconsistent with the limits of this work. An account of his new system of crystallography is given by one of his pupils in the 3d vol. of the Edin. Phil. Journal. But the Professor promises soon to publish that system himself; which, if we may judge from the luminous exposition of the *characteristic of his* NATURAL HISTORY SYSTEM, recently published, will be an immense acquisition to mineralogical science.*

* **MINERAL CAOUTCHOUC.** See CAOUTCHOUC.*

* **MINERAL CHARCOAL.** See CHARCOAL (MINERAL).*

* **MINERAL OIL.** See PETROLEUM.*

* **MINERAL PITCH.** See BITUMEN.*

MINERALIZER. Metallic substances are said to be mineralized, when deprived of their usual properties by combination with some other substance.

MINIUM. Red oxide of lead.

MIRRORS. See SPECULUM; also SILVERING.

* **MISPICKEL.** Common arsenical pyrites.*

* **MOCHA-STONE.** See AGATE.*

* **MOLYBDATE OF LEAD.** See ORES OF LEAD.*

MOLYBDENUM. A metal which has not yet been reduced into masses of any magnitude; but has been obtained only in small separate globules, in a blackish brilliant mass. This may be effected by making its acid into a paste with oil, bedding it in charcoal in a crucible, and exposing it to an intense heat. The globules are gray, brittle, and extremely infusible. By heat it is converted into a white oxide, which rises in brilliant needle-formed flowers, like those of antimony. Nitric acid readily oxidizes and acidifies the metal. Nitre detonates with it, and the remaining alkali combines with its oxide.

Molybdenum unites with several of the metals, and forms brittle or friable compounds. No acid acts on it but the nitric and nitromuriatic. Several acids act on its oxide, and afford blue solutions. See ACID (MOLYBDIC).

* The sp. gr. of molybdenum is 8.611. When dry molybdate of ammonia is ignited in a crucible with charcoal powder, it is converted into the brown oxide of the metal. This has a crystallized appearance, a copper-brown colour, and a sp. gr. of 5.66. It does not form salts with acids. The deutoxide is molybdous acid, which see.*

* **MONTMARTRITE.** Its colour is yellowish; it occurs massive, but never crystallized. It is soft. It effervesces with nitric acid. It is a compound of 83 sulphate of lime, and 17 carbonate of lime, which is found at Montmartre, near Paris. It stands the weather, which common gypsum does not bear.*

* **MOONSTONE.** A variety of Adularia.*

* **MOOR-COAL.** See COAL.*

* **MORASS-ORE.** Bog-iron ore.*

* **MOROXYLIC ACID.** See ACID (MOROXYLIC).*

* **MORPHIA.** A new vegetable alkali, extracted from opium, of which it constitutes the narcotic principle. It was first obtained pure, by M. Sertürner, about the year 1817.

Two somewhat different processes for procuring it, have been given by M. Robiquet, and M. Choulant.

According to the former, concentrated infusion of opium is to be boiled with a small quantity of common magnesia for a quarter of an hour. A considerable quantity of a grayish deposite falls. This is to be washed on a filter with cold water, and, when dry, acted on by weak alcohol for some time, at a temperature beneath ebullition. In this way very little morphia, but a great quantity of colouring matter, is separated. The acid matter is then to be drained on a filter, washed with a little cold alcohol, and afterwards boiled with a large quantity of highly rectified alcohol. This liquid being filtered while hot, on cooling it deposites the morphia in crystals, and very little coloured. The solution in alcohol and crystallization being repeated two or three times, colourless morphia is obtained.

The theory of this process is the following:—Opium contains a meconiate of morphia. The magnesia combines with the meconic acid, and the morphia is displaced.

Choulant directs us to concentrate a dilute watery infusion of opium, and leave it at rest till it spontaneously let fall its sulphate of lime in minute crystals. Evaporate to dryness; redissolve in a little water, and throw down any remaining lime and sulphuric acid, by the cautious addition, first of oxalate of ammonia, and then of muriate of barytes. Dilute the liquid with a large body of water, and add caustic ammonia to it, as long as any precipitate falls. Dissolve this in vinegar, and throw it down again with ammonia. Digest on the precipitate about twice its weight of sulphuric ether, and throw the whole upon a filter. The dry powder is to be digested three times in caustic ammonia, and as often in cold alcohol. The remaining powder being dissolved in twelve ounces of boiling alcohol, and the filtered hot solution being set aside for 18 hours, deposites colourless transparent crystals, consisting of double pyramids. By concentrating the supernatent alcoholic solution, more crystals may be obtained.

Dr. Thomson directs us to pour caustic

ammonia into a strong infusion of opium, and to separate the brownish-white precipitate by the filter; to evaporate the infusion to about one-sixth of its volume, and mix the concentrated liquid with more ammonia. A new deposite of impure morphia is obtained. Let the whole of the deposites be collected on the filter, and washed with cold water. When well drained, pour a little alcohol on it, and let the alcoholic liquid pass through the filter It will carry off a good deal of the colouring matter, and very little of the morphia. "Dissolve the impure morphia thus obtained, in acetic acid, and mix the solution, which has a very deep brown colour, with a sufficient quantity of ivory-black. This mixture is to be frequently agitated for 24 hours, and then thrown on the filter. The liquid passes through quite colourless. If ammonia be now dropped into it, pure morphia falls in the state of a white powder. If we dissolve this precipitate in alcohol, and evaporate that liquid slowly, we obtain the morphia, in pretty regular crystals. It is perfectly white, has a pearly lustre, is destitute of smell, but has an intensely bitter taste, and the shape of the crystals in all my trials, was a four-sided rectangular prism." Annals of Phil. June 1820. On the above process I have only to remark, that the acetic solution must contain a good deal of phosphate of lime, derived from the ivory-black; and that therefore those who have used that precipitate for morphia in medicine, have been disappointed. The subsequent solution in alcohol, however, and crystallization, render it pure.

M. Choulant says, it crystallizes in double four-sided pyramids, whose bases are squares or rectangles. Sometimes in prisms with trapezoidal bases.

It dissolves in 82 times its weight of boiling water, and the solution on cooling deposites regular, colourless transparent crystals. It is soluble in 36 times its weight of boiling alcohol, and in 42 times its weight of cold alcohol, of 0.92. It dissolves in eight times its weight of sulphuric ether. All these solutions change the infusion of brazil-wood to violet, and the tincture of rhubarb to brown. The saturated alcoholic and ethereous solutions, when rubbed on the skin, leave a red mark.

Sulphate of morphia crystallizes in prisms, which dissolve in twice their weight of distilled water. They are composed of

Acid,	22	5.00
Morphia,	40	9.09
Water,	38	
	100	

Nitrate of morphia yields needle-form crystals in stars, which are soluble in 1½ times their weight of distilled water. Its constituents are,

Acid,	20	6.75
Morphia,	36	12.15
Water,	44	
	100	

Muriate of morphia, is in feather-shaped crystals, and needles. It is soluble in 10½ times its weight of distilled water. Its constituents are,

Acid,	35	4.625
Morphia,	41	5.132
Water,	24	
	100	

The acetate crystallizes in needles; the tartrate in prisms; and the carbonate in short prisms. Dr. Thomson states the ultimate constituents of morphia to be,

Hydrogen,	0.0555
Carbon,	0.4528
Oxygen,	0.4917
	1.0000

from the analysis of one grain, by ignited peroxide of copper. He imagines the atom to be either 40.25, or 20.125. The former number approaches to that of Pelletier and Caventou; the latter is much greater than any of Choulant's, deduced from the above saline combinations, the mean of which gives about 8.25.

Morphia acts with great energy on the animal economy. A grain and a half taken at three different times, produced such violent symptoms upon three young men of 17 years of age, that Sertürner was alarmed, lest the consequences should have proved fatal.

Morphia, according to its discoverer, melts in a gentle heat; and in that state has very much the appearance of melted sulphur. On cooling, it again crystallizes. It burns easily; and when heated in close vessels, leaves a solid, resinous, black matter, having a peculiar smell.*

* **MORTAR CEMENT.** A mixture of lime, and siliceous sand, used in masonry for cementing together the stones and bricks of a building. The most precise ideas which we have on this subject, were given by Sir H. Davy in his Agric. Chem. See LIME.*

* **MOSAIC GOLD.** See AURUM MUSIVUM.*

* **MOTHER OF PEARL** shells are composed of alternate layers of coagulated albumen and carbonate of lime, in the proportion, by Mr. Hatchett, of 24 of the former and 76 of the latter, in 100 parts.*

MOTHER WATER. When sea-water or any other solution containing various salts, is evaporated, and the crystals taken out; there always remains a fluid containing deliquescent salts, and the impurities, if present. This is called the mother water.

MOULD. See SOIL, MANURE, and ANALYSIS (VEGETABLE).

* MOUNTAIN BLUE. Malachite; carbonate of copper.*

* MOUNTAIN CORK and MOUNTAIN LEATHER. See ASBESTUS.*

* MOUNTAIN GREEN. Common copper green; a carbonate of copper.*

* MOUNTAIN or ROCK WOOD. See ASBESTUS.*

* MOUNTAIN SOAP. Colour pale brownish-black. Massive. Dull. Fracture fine earthy. Opaque. Streak shining. Writes, but does not soil. Soft. Sectile. Easily frangible. Adheres strongly to the tongue. Feels very greasy. It is light, bordering on rather heavy. It occurs in trap-rocks in the island of Skye. It is used in crayon-painting.*

* MUCILAGE. An aqueous solution of gum.*

MUCUS. This, according to Dr. Bostock, is one of the primary animal fluids, perfectly distinct from gelatin.

The subacetate of lead does not affect gelatin; on the other hand, tannin, which is a delicate test of gelatin, does not affect mucus. Both these reagents, however, precipitate albumen; but the oxymuriate of mercury, which will indicate the presence of albumen dissolved in 2000 parts of water, precipitates neither mucus nor gelatin. Thus we have three distinct and delicate tests for these three different principles.

Gum appears to resemble mucus in its properties. One grain of gum-arabic, dissolved in 200 of water, was not affected by oxymuriate of mercury, or by tannin, but was immediately precipitated by subacetate of lead.

MUFFLE. A small earthen oven, made and sold by the crucible manufacturers. It is to be fixed in a furnace, and is useful for cupellation, and other processes which demand access of air.

* MURIACITE. Gypsum.*

* MURIATIC ACID. See ACID (MURIATIC).*

* MURICALCITE. Rhomb-spar.*

* MUSCLES OF ANIMALS. See FIBRIN and FLESH.*

* MUSCOVY GLASS. Mica.*

* MUSHROOMS See BOLETUS.*

* MUSSITE. Diopside.*

* MUST. The juice of grape, composed of water, sugar, jelly, gluten, and bitartrate of potash. From a French wine pint of *must*, the Marquis de Bullion extracted half an ounce of sugar, and 1-16th of an ounce of tartar. Proust says, the muscadine grape contains about 30 per cent of a peculiar species of sugar. By fermentation, it forms wine.*

* MYRICIN. The ingredient of wax which remains after digestion with alcohol. It is insoluble likewise in water and ether; but very soluble in fixed and volatile oils. Its melting point is about 120°. Sp. gr. 0.90. Its consistence is waxy.*

* MYRRH. A gum-resin, which consists, according to Braconnot, of

Resin, containing some volatile oil,	33.68
Gum, - - - - - -	66.32
	100.00

N

NACRITE. See TALCITE.

* NADELSTEIN. Rutile.*

* NAILS consist of coagulated albumen, with a little phosphate of lime.*

NANKIN DYE. See IRON, towards the end.

* NAPHTHA. A native combustible liquid, of a yellowish-white colour; perfectly fluid and shining. It feels greasy, exhales an agreeable bituminous smell, and has a specific gravity of about 0.7. It takes fire on the approach of flame, affording a bright white light. It occurs in considerable springs on the shores of the Caspian Sea, in Sicily and Italy. It is used instead of oil, and differs from the petroleum obtained by distilling coal tar, only by its greater purity and lightness. By Dr. Thomson's recent analysis of a specimen of naphtha from Persia, whose sp. gr. was 0.753, and boiling point 320°, it appears to be composed of carbon 82.2 + hydrogen 14.8, with perhaps a little azote.*

NAPLES YELLOW. According to Professor Beckmann, this colour is prepared by calcining lead with antimony and potash in a reverberatory furnace.

* NATRON. Native carbonate of soda, of which there are two kinds, the common and radiated. See SODA.*

* NATROLITE. A sub-species of prismatic zeolite or mesotype. Colour yellowish. Massive, in plates, and reniform. Seldom crystallized. Crystals acicular. Lustre glistening, pearly. Translucent on the edges. Sp. gr. 2.2. Before the blow-pipe, it becomes first black, then red, intumesces, and melts into a white compact glass. Its constituents are, silica 48.0, alumina 24.25, natron, 16.5, oxide of iron 1.75, and water 9. It occurs in chalkstone porphyry in Wurtemberg and Bohemia, and in the trap-tuff hill named the Bin, behind Bruntisland in Scotland*.

* NEEDLE ORE Acicular bismuth-glance.*

* **Needle Zeolite.** Colour grayish-white. Massive; in distinct concretions; and crystallized in acicular rectangular four-sided prisms, variously acuminated and truncated. The lateral planes are longitudinally streaked. Glistening, inclining to pearly. Cleavage twofold, in the direction of the lateral plane of the prism. Translucent. Refracts double. As hard as apatite. Brittle. Sp. gr 2.3. It intumesces before the blow-pipe, and forms a jelly with acids. It becomes electric by heating, and retains this property some time after it has cooled. The free extremity of the crystal, with the acumination, shows positive, and the attached end negative electricity. Its constituents are, silica 50.24, alumina 29.3, lime 9.46. water 10. It occurs in secondary trap-rocks near the village of Old Kilpatrick in Scotland.*

* **Nepheline.** Rhomboidal feldspar. Colour white. Massive and crystallized. The primitive form is a di-rhomboid of 152° 44′, and 56° 15′. The secondary forms are, a perfect equiangular six-sided prism; the same truncated on the terminal edges; and a thick six-sided table, with the lateral edges all truncated. The crystals form druses. Lustre splendent, vitreous. Cleavage fourfold. Fracture conchoidal. Translucent and transparent. As hard as feldspar. Sp. gr. 2.6 to 2.7. It melts with difficulty before the blow-pipe. Its constituents are, silica 46, alumina 49, lime 2, oxide of iron 1. It occurs in drusy cavities, along with ceylanite, vesuvian and meionite, at Monte Somma, near Naples, in drusy cavities, in granular limestone.*

Nephrite. Of which mineral there are two kinds; common nephrite and axe-stone.

Common nephrite. Colour leek-green. Massive and in rolled pieces. Dull. Fracture coarse splintery. Translucent. Nearly as hard as rock-crystal. Difficultly frangible. Feels rather greasy. Rather brittle. Sp. gr. 3. It melts before the blow-pipe into a white enamel. Its constituents are, silica 50.5, magnesia 31, alumina 10, iron 5.5, chrome 0.05, water 2.75. Nephrite occurs in granite and gneiss, in Switzerland; and in veins that traverse primitive greenstone in the Hartz. The most beautiful come from Persia and Egypt. The South American variety is called Amazon-stone, from its locality.* See **Axe-Stone.**

* **Nerium Tinctorium.** A tree growing in Hindostan, which, according to Dr. Roxburgh, affords indigo.*

* **Neutralization.** When acid and alkaline matter are combined in such proportions that the compound does not change the colour of litmus or violets, they are said to be neutralized.*

Nickel is a metal of great hardness, of a uniform texture, and of a colour between silver and tin; very difficult to be purified, and magnetical. It even acquires polarity by the touch. It is malleable, both cold and red-hot; and is scarcely more fusible than manganese. Its oxides, when pure, are reducible by a sufficient heat without combustible matter; and it is little more tarnished by heating in contact with air, than platina, gold, and silver. Its specific gravity when cast, is 8.279; when forged, 8.666.

Nickel is commonly obtained from its sulphuret, the kupfernickel of the Germans, in which it is generally mixed also with arsenic, iron, and cobalt. This is first roasted, to drive off the sulphur and arsenic, then mixed with two parts of black flux, put into a crucible, covered with muriate of soda, and heated in a forge furnace. The metal thus obtained, which is still very impure, must be dissolved in dilute nitric acid, and then evaporated to dryness; and after this process has been repeated three or four times, the residuum must be dissolved in a solution of ammonia, perfectly free from carbonic acid. Being again evaporated to dryness, it is now to be well mixed with two or three parts of black flux, and exposed to a violent heat in a crucible for half an hour or more.

According to Richter, the oxide is more easily reduced, by moistening with a little oil. Thenard advises to pour chloride of lime on the oxide of nickel, and shake them well together, before the ammonia is added; as thus the oxides of cobalt and iron, if present, will be so much saturated with oxygen, as to be insoluble in the ammonia, and consequently may be separated.

M. Chenevix observed, that a very small portion of arsenic prevents nickel from being affected by the magnet. Richter found the same. When it is not attractible, therefore, we may be pretty certain that this is present. To separate the arsenic, M. Chenevix boiled the compound in nitric acid, till the nickel was converted into an arseniate; decomposed this by nitrate of lead; and evaporated the liquor, not quite to dryness. He then poured in alcohol, which dissolved only the nitrate of nickel. The alcohol being decanted and evaporated, he redissolved the nitrate in water, and precipitated by potash. The precipitate, well washed and dried, he reduced in a Hessian crucible lined with lampblack, and found it to be perfectly magnetic; but this property was destroyed again, by alloying the metal with a small portion of arsenic. Alloying it with copper weakens this property.

*There are two oxides of nickel; the dark ash-gray, and the black. If potash be added to the solution of the nitrate or sulphate, and the precipitate dried, we obtain the protoxide. It may be regarded as a compound of about 100 metal with 28 of oxygen; and the prime equivalent of the metal will become 3.6, while that of the protoxide will be 4.6. The preoxide was formed by Thenard, by passing chlorine through the protoxide diffused in water. A black insoluble peroxide remains at the bottom.

Little is known of the chloride, iodide, sulphuret, or phosphuret of this metal. A compound, resembling meteoric iron, has been made, by fusing together about 5 or 10 parts of nickel with 95 or 90 of iron. The meteoric iron from Baffin's Bay contains 3 per cent of nickel; the Siberian contains 10 per cent, by Mr. Children's accurate analysis.—*See Journal of Science*, vol. ix.

The salts of nickel possess the following general characters. They have usually a green colour, and yield a white precipitate with ferroprussiate of potash. Ammonia dissolves the oxide of nickel. Sulphuretted hydrogen and infusion of galls occasion no precipitate. The hydrosulphuret of potash throws down a black precipitate. Their composition has been very imperfectly ascertained.*

The sulphuric and muriatic acids have little action upon nickel. The nitric and nitro-muriatic are its most appropriate solvents. The nitric solution is of a fine grass-green colour. Carbonate of potash throws down from it a pale apple-green precipitate, which, when well washed and dried, is very light. One part of metal gives 2.927 of this precipitate, which by exposure to a white heat becomes blackish-gray, barely inclining to green, and weighing only 1.285. By continuing the fire it is reduced

When ammonia is added in excess to a nitric solution of nickel, a blue precipitate is formed, which changes to a purple-red in a few hours, and is converted to an apple-green by an acid. If the precipitate retain its blue colour, copper is present.

* **Nicotin.** A peculiar principle obtained by Vauquelin from tobacco. It is colourless, and has the peculiar taste and smell of the plant. It dissolves both in water and alcohol; is volatile, poisonous, and precipitable from its solutions by tincture of galls. —*Ann. de Chimie*, tom. lxxi.*

* **Nigrine.** An ore of titanium.*

Nihil Album. A name formerly given to the flowers or white oxide of zinc.

* **Nitrates.** Compounds of nitric acid with the salifiable bases.*

Nitre. The common name of the nitrate of potash. See Acid (Nitric).*

* **Nitrogen, or Azote**, an important elementary, or undecompounded principle. As it constitutes four-fifths of the volume of atmospheric air, the readiest mode of procuring azote, is to abstract its oxygenous associate, by the combustion of phosphorus, or hydrogen. It may also be obtained from animal matters, subjected in a glass retort to the action of nitric acid, diluted with 8 or 10 times its weight of water.

Azote possesses all the physical properties of air. It extinguishes flame and animal life. It is absorbable by about 100 volumes of water. Its spec. gravity is 0.9722. 100 cubic inches weigh 29.65 grains. It has neither taste nor smell. It unites with oxygen in four proportions, forming four important compounds. These are

1. Protoxide of azote, or nitrous oxide.
2. Deutoxide of azote, nitrous gas, or nitric oxide.
3. Nitrous acid.
4. Nitric acid.

1. *Nitrous oxide*, or *protoxide of azote*, was discovered by Dr. Priestley in 1772, but was first accurately investigated by Sir H. Davy in 1799. The best mode of procuring it, is to expose the salt called nitrate of ammonia, to the flame of an Argand lamp, in a glass retort. When the temperature reaches 400° F. a whitish cloud will begin to project itself into the neck of the retort, accompanied by the copious evolution of gas, which must be collected over mercury for accurate researches, but for common experiments may be received over water. It has all the physical properties of air. It has a sweet taste, a faint agreeable odour, and is condensible by about its own volume of water, previously deprived of its atmospheric air. This property enables us to determine the purity of nitrous oxide. A taper plunged into this gas, burns with great brilliancy; the flame being surrounded with a bluish halo. But phosphorus may be melted and sublimed in it, without taking fire. When this combustible is introduced into it, in a state of vivid combustion, the brilliancy of the flame is greatly increased. Sulphur and most other combustible bodies, require a higher degree of heat for their combustion in it, than in either oxygen or common air. This may be attributed to the counteracting affinity of the intimately combined azote. Its sp. grav. is 1.5277. 100 cubic inches weigh 46.6 gr. It is respirable, but not fitted to support life. Sir H. Davy first showed, that by breathing a few quarts of it, contained in a silk bag, for two or three minutes, effects analogous to those occasioned by drinking fermented liquors, were produced. Individuals, who differ in temperament, are, however, as we might expect, differently affected.

Sir H. Davy describes the effect it had upon him, as follows:—"Having previously closed my nostrils, and exhausted my lungs, I breathed four quarts of nitrous oxide from and into a silk bag. The first feelings were similar to those produced in the last experiment, (giddiness); but in less than half a minute, the respiration being continued, they diminished gradually, and were succeeded by a sensation analogous to gentle pressure on all the muscles, attended by an highly pleasurable thrilling, particularly in the chest and the extremities. The objects around me became dazzling, and my hearing more acute. Towards the last inspiration the thrilling increased, the sense of muscular power became greater, and at last an irresistible propensity to action was indulged in. I recollected but indistinctly what followed; I know that my motions were various and violent.

"These effects very soon ceased after respiration. In ten minutes I had recovered my natural state of mind. The thrilling in the extremities continued longer than the other sensations."

"The gas has been breathed by a very great number of persons, and almost every one has observed the same things. On some few, indeed, it has no effect whatever, and on others the effects are always painful.

"Mr. J. W. Tobin, (after the first imperfect trials), when the air was pure, experienced sometimes sublime emotions with tranquil gestures, sometimes violent muscular action, with sensations indescribably exquisite; no subsequent debility—no exhaustion;—his trials have been very numerous. Of late he has only felt sedate pleasure. In Sir H. Davy the effect is not diminished.

"Mr. James Thomson. Involuntary laughter, thrilling in his toes and fingers, exquisite sensations of pleasure A pain in the back and knees, occasioned by fatigue the day before, recurred a few minutes afterwards. A similar observation, we think, we have made on others; and we impute it to the undoubted power of the gas to increase the sensibility or nervous power, beyond any other agent, and probably in a peculiar manner.

"Mr. Thomas Pople. At first unpleasant feelings of tension; afterwards agreeable luxurious languor, with suspension of muscular power; lastly, powers increased both of body and mind.

"Mr. Stephen Hammick, surgeon of the Royal Hospital, Plymouth. In a small dose, yawning and languor. It should be observed that the first sensation has often been disagreeable, as giddiness; and a few persons, previously apprehensive, have left off inhaling as soon as they felt this. Two larger doses produced a glow, unrestrainable tendency to muscular action, high spirits and more vivid ideas A bag of common air was first given to Mr. Hammick, and he observed that it produced no effect. The same precaution against the delusions of imagination was of course frequently taken.

"Mr. Robert Southey could not distinguish between the first effects and an apprehension of which he was unable to divest himself. His first definite sensations were, a fullness and dizziness in the head, such as to induce a fear of falling. This was succeeded by a laugh which was involuntary, but highly pleasurable, accompanied with a peculiar thrilling in the extremities, a sensation perfectly new and delightful. For many hours after this experiment, he imagined that his taste and smell were more acute, and is certain that he felt unusually strong and cheerful. In a second experiment, he felt pleasure still superior, and has once poetically remarked, that he supposes the atmosphere of the highest of all possible heavens to be composed of this gas.

"Robert Kinglake, M. D. Additional freedom and power of respiration, succeeded by an almost delirious, but highly pleasurable sensation in the head, which became universal, with increased tone of the muscles. At last, an intoxicating placidity absorbed for five minutes all voluntary power, and left a cheerfulness and alacrity for several hours. A second stronger dose produced a perfect trance for about a minute; then a glow pervaded the system. The permanent effects were an invigorated feeling of vital power, and improved spirits. By both trials, particularly by the former, old rheumatic feelings seemed to be revived for the moment.

"Mr. Wedgwood breathed atmospheric air first, without knowing it was so. He declared it to have no effect, which confirmed him in his disbelief of the power of the gas. After breathing this some time, however, he threw the bag from him, kept breathing on laboriously with an open mouth, holding his nose with his left hand, without power to take it away, though aware of the ludicrousness of his situation; all his muscles seemed to be thrown into vibrating motions; he had a violent inclination to make antic gestures, seemed lighter than the atmosphere, and as if about to mount. Before the experiment, he was a good deal fatigued after a long ride, of which he permanently lost all sense. In a second experiment, nearly the same effect, but with less pleasure. In a third, much greater pleasure." *Res. on. nit. ox.*

I have often verified these pleasurable effects, on myself and my pupils. The causes of failure, in most cases, I believe to be, impure gas, a narrow tube or stop-cock, or precipitate breathing from fear. If a little sulphate or muriate be mixed with the nitrate of ammonia, it will not yield an intoxicating gas. I use a pretty wide glass tube, fixed to the mouth of a large bladder.

I find that mice, introduced into a jar containing nitrous oxide, die almost instantly; while in azote, hydrogen, and carbonic acid, they struggle for a little while.

This gaseous compound may be analyzed by the combustion of hydrogen, carbon, or phosphorus in it. If we mix 100 volumes of nitrous oxide with 100 of hydrogen; and detonate the mixture in an explosive eudiometer, nothing will remain but 100 measures of azote. Hence 50 measures of oxygen, the equivalent quantity of 100 of hydrogen, must have existed in the oxide. It therefore consists of 100 measures of azote + 50 of oxygen, condensed by reciprocal attraction, into only 100 measures.

Now 100 vol. of azote, weigh	0.9722
50 of oxygen, $\frac{1.1111}{2}$ =	0.5555
	1.5277

This synthetic sum exactly coincides with the specific gravity of the compound. It is therefore composed by weight of one

prime equivalent of azote, =	1.75	63.64
one of oxygen, =	1.00	36.36
	2.75	100.00

The weight of the compound prime, is the same with that of carbonic acid.

Iron wire burns with brilliancy in the above gas, but it is soon extinguished.

2. *Deutoxide of azote*, or *nitric oxide*, was first described by Dr. Priestley in 1772. Into a glass retort, containing copper turnings, pour nitric acid diluted with 6 or 8 times its quantity of water, and apply a gentle heat. A gas comes over, which may be collected over water; but for exact experiments, it should be received over mercury. Its sp. gr. is 1.0416. 100 cubic inches weigh 36.77 grains. Water condenses only about $\frac{1}{20}$ of its volume of nitric oxide. But a solution of protosulphate or protomuriate of iron, absorbs it very copiously, forming a dark coloured liquid, which is used for condensing oxygen, in the eudiometer of Sir H. Davy.

When a jar of nitric oxide is opened in the atmosphere, red fumes appear, in consequence of the absorption of oxygen, and formation of nitrous acid. When an animal is made to inhale this gas, it is instantly destroyed by the formation of this acid, and condensation of the oxygen, in its lungs. When a burning taper is immersed in this gas, it is extinguished; as well as the flame of sulphur. But inflamed phosphorus burns in it with great splendour. A mixture of hydrogen gas and nitric oxide, burns with a lambent green flame, but does not explode by the electric spark; though Fourcroy says that it detonates on being passed through an ignited porcelain tube. The pyrophorus of Homberg spontaneously burns in it.

It is decomposable by several of the metals, when they are heated in it, such as arsenic, zinc, and potassium in excess. It oxidizes them, and affords half its volume of azote. Charcoal ignited in it, by a burning glass, produces half a volume of azote, and half a volume of carbonic acid. All these analytical experiments concur to show, that nitric oxide consists of oxygen and azote, in equal volumes. Hence, if we take the mean weight of a volume of each gas, we shall have that of the gaseous compound; or, its sp. gr.

		Sum.	*Hf. sum or sp. gr.*
Azote,	0.9722	2.0833	1.0416.
Oxygen,	1.1111		

If we convert these into equivalent ratios, we shall have the gas composed of

1 prime of azote =	1.75	46.66
2 primes oxygen =	2.00	53.33
		100.00

When this deutoxide is exposed at ordinary temperatures, to bodies which have a strong attraction for oxygen, such as the sulphites, protomuriate of tin, and the alkaline hydrosulphurets, two volumes of it are converted into one volume of the protoxide. We see here, that when one prime of oxygen is abstracted, the remaining one enters into a denser state of union with azote.*

For the habitudes of this gas with hydrogen, see AMMONIA; and with oxygen, see EUDIOMETER, and NITRIC and NITROUS ACIDS.

Azote combines with chlorine and iodine, to form two very formidable compounds.

1. The chloride of azote was discovered about the beginning of 1812, by M. Dulong; but its nature was first investigated and ascertained by Sir H. Davy.

Put into an evaporating porcelain basin, a solution of one part of nitrate or muriate of ammonia in 10 of water, heated to about 100°, and invert into it a wide mouthed bottle filled with chlorine. As the liquid ascends by the condensation of the gas, oily-looking drops are seen floating on its surface, which collect together, and fall to the bottom in large globules. This is *chloride of azote*. By putting a thin stratum of common salt into the bottom of the basin, we prevent the decomposition of the chloride of azote, by the ammoniacal salt. It should be formed only in very small quantities. The *chloride of azote* thus obtained, is an oily-looking liquid; of a yellow colour; and a very pungent intolerable odour, similar to that of chloro-carbonous acid. Its sp. gr. is 1.653. When tepid water is poured into a glass containing it, it expands into a volume of elastic fluid, of an orange colour, which diminishes as it passes through the water.

"I attempted," says Sir H. Davy, "to collect the products of the explosion of the new substance, by applying the heat of a spirit-lamp to a globule of it, confined in a curved glass tube over water: a little gas was at first extricated; but long before the water had attained the temperature of ebullition, a violent flash of light was perceived, with a sharp report; the tube and glass were broken into small fragments, and I received a severe wound in the transparent *cornea* of the eye, which has produced a considerable inflammation of the eye, and obliges me to make this communication by an amanuensis. This experiment proves what *extreme* caution is necessary in operating on this substance; for the quantity I used was scarcely as large as a grain of mustard-seed." Phil. Tran. 1813, part I. It evaporates pretty rapidly in the air; and *in vacuo* it expands into a vapour, which still possesses the power of exploding by heat. When it is cooled artificially in water, or the ammoniacal solution, to 40° F., the surrounding fluid congeals; but when alone, it may be surrounded with a mixture of ice and muriate of lime, without freezing.

It gradually disappears in water, producing azote; while the water becomes acid, acquiring the taste and smell of a weak solution of nitro-muriatic acid.

With muriatic and nitric acids, it yields azote; and with dilute sulphuric acid, a mixture of azote and oxygen. In strong solutions of ammonia it detonates; with weak ones, it affords azote.

When it was exposed to pure mercury, out of the contact of water, a white powder (calomel) and azote were the results. "The action of mercury on the compound," says Sir H. "appeared to offer a more correct and less dangerous mode of attempting its analysis; but on introducing two grains, under a glass tube filled with mercury and inverted, a violent detonation occurred, by which I was slightly wounded in the head and hands, and should have been severely wounded, had not my eyes and face been defended by a plate of glass, attached to a proper cap; a precaution very necessary in all investigations of this body."—Phil. Trans. 1813, part 2d. In using smaller quantities, and recently distilled mercury, he obtained the results of the experiments, without any violence of action.

From his admirable experiments on the analysis of this formidable substance, by mercury, by muriatic acid, and from the discoloration of sulphate of indigo, we may infer its composition to be

4 vol. of chlorine = 10. 4 primes 18.0
1 of azote = 0.9722 1 1.75

or very nearly 10 by weight of chlorine to 1 of azote.

A small globule of it, thrown into a glass of olive oil, produced a most violent explosion; and the glass though strong, was broken into fragments. Similar effects were produced by its action on oil of turpentine and naphtha. When it was thrown into ether or alcohol, there was a very slight action. When a particle of it was touched under water by a particle of phosphorus, a brilliant light was perceived under the water, and permanent gas was disengaged, having the characters of azote.

When quantities larger than a grain of mustard-seed were used for the contact with phosphorus, the explosion was always so violent as to break the vessel in which the experiment was made. On tinfoil and zinc it exerted no action; nor on sulphur and resin. But it detonated most violently when thrown into a solution of phosphorus in ether or alcohol.

The mechanical force of this compound in detonation, seems superior to that of any other known, not even excepting the ammoniacal fulminating silver. The velocity of its action appears to be likewise greater. I touched a minute globule of it, in a platina spoon resting on a table, with a fragment of phosphorus at the point of a penknife. The blade was instantly shivered into fragments by the explosion.

Messrs. Porret, Wilson, and Rupert Kirk, brought 125 different substances in contact with it. The following were the only ones which caused it to explode:—

Supersulphuretted hydrogen.
Phosphorus.
Phosphuret of lime.
Phosphuretted camphor.
Camphuretted oil.
Phosphuretted hydrogen gas.
Caoutchouc.
Myrrh.
Palm oil.
Ambergris.
Whale oil.
Linseed oil.
Olive oil.
Sulphuretted oil.
Oil of turpentine.
—— tar.
—— amber.
—— petroleum.
—— orange-peel.
Naphtha.
Soap of silver.
——— mercury.
——— copper.
——— lead.
——— manganese.
Fused potash.
Aqueous ammonia.
Nitrous gas.—*Nich. Journ.* vol. 34.

2. *Iodide of azote* Azote does not combine directly with iodine. We obtain the combination only by means of ammonia. It was discovered by M. Courtois, and carefully examined by M. Colin. When ammoniacal gas is passed over iodine, a viscid shining liquid is immediately formed of a brownish-black colour, which, in proportion as it is saturated with ammonia, loses its lustre and viscosity. No gas is disengaged during the formation of this liquid, which may be called *iodide of ammonia*. It is not fulminating. When dissolved in water, a part of the ammonia is decomposed; its hydrogen forms hydriodic acid; and its azote combines with a portion of the iodine,

and forms the fulminating powder. We may obtain the iodide of azote directly, by putting pulverulent iodine into common water of ammonia. This indeed is the best way of preparing it; for the water is not decomposed, and seems to concur in the production of this iodide, only by determining the formation of hydriodate of ammonia.

The iodide of azote is pulverulent, and of a brownish-black colour. It detonates from the smallest shock, and from heat, with a feeble violet vapour. When properly prepared, it often detonates spontaneously. Hence, after the black powder is formed, and the liquid ammonia decanted off, we must leave the capsule containing it in perfect repose.

When this iodide is put into potash water, azote is disengaged, and the same products are obtained, as when iodine is dissolved in that alkaline lixivium. The hydriodate of ammonia, which has the property of dissolving a great deal of iodine, gradually decomposes the fulminating powder, while azote is set at liberty. Water itself has this property, though in a much lower degree. As the elements of iodide of azote are so feebly united, it ought to be prepared with great precautions, and should not be preserved. In the act of transferring a little of it from a platina capsule to a piece of paper, the whole exploded in my hands, though the friction of the particles on each other was inappreciably small.

Both Sir H. Davy and M. Gay-Lussac have exploded their iodide in glass tubes, and collected the results. The latter states, "that if we decompose a gramme (15.444 grains) of the fulminating powder, we obtain, at the temperature of 32°, and under the pressure of 30 inches of mercury, a gaseous mixture amounting to 0.1152 litre, (7.03 cubic inches), and composed of 0.0864 of the vapour of iodine, and 0.0288 of azote." —*Ann. de Chimie*, xci. Now 0.0864 is to 0.0288 as 3 to 1 exactly. Therefore the detonating powder consists of

3vols. of the va. of iod. = 8.63 × 3 = 25.89
1vol. of azote - - = 0.9722

or reduced to the oxygen equivalent scale, it consists of

3 primes of iodine	=	46.5	96.37
1 azote	=	1.75	3.63
			100.00

Azote has hitherto resisted all attempts to decompose it. Sir H. Davy volatilized the highly combustible metal potassium in azote over mercury, and passed the voltaic flame of 2000 double plates through the vapour, but the azote underwent no change. He made also many other attempts to decompose it, but they were unsuccessful.

In my experiments on the ammoniacal salts, I found, that when dry lime and muriate of ammonia were ignited together in a Reaumur porcelain tube, connected with water in a Woulfe's apparatus, a portion of ammonia constantly disappeared, or was annihilated, while nothing but water was obtained to replace that loss. "Of the tightness of the apparatus I am well assured. Indeed I have performed the experiment, with a continuous glass tube, sealed and bent down at one end like a retort, while the other end was drawn into a small tube, which passed under a jar on the mercurial pneumatic shelf. The middle part was kept horizontal and artificially cooled. The sealed end contained the mixture of lime and sal ammoniac. A brush flame of a large alcohol blow-pipe was made to play very gently on the end of the tube at first, but afterwards so powerfully, as to keep it ignited for some time. The sal ammoniac recovered, did not exceed three-fourths of that originally employed." The sal ammoniac was regenerated by saturating the ammonia with muriatic acid, and cautious evaporation. *See Ann. of Phil. September* 1817.

The strongest arguments for the compound nature of azote are derived from its slight tendency to combination, and from its being found abundantly in the organs of animals, which feed on substances that do not contain it.

Its uses in the economy of the globe are little understood. This is likewise favourable to the idea that the real chemical nature is as yet unknown, and leads to the hope of its being decomposable.

It would appear that the atmospheric azote and oxygen spontaneously combine in other proportions, under certain circumstances, in natural operations. Thus we find, that mild calcareous or alkaline matter favours the formation of nitric acid, in certain regions of the earth; and that they are essential to its production in our artificial arrangements, for forming nitre from decomposing animal and vegetable substances.*

Nitrous Acid. See Acid (Nitrous).

Noble Metals. This absurd name has been bestowed on the perfect metals, gold, silver, and platina.

* Novaculite. Whetslate.*

* Nux Vomica. See Strychnia.*

O

* **OBSIDIAN.** Of this mineral there are two kinds, the translucent and transparent.

1. *Translucent obsidian.* Colour velvet-black. Massive. Specular splendent. Fracture perfect conchoidal. Translucent, or translucent on the edges. Hard. Very brittle. Easily frangible. Streak gray. Sp. gr. 2.37. It melts, or becomes spongy before the blow-pipe. Its constituents are, silica 78, alumina 10, lime 1, soda 1.6, potash 6, oxide of iron 1.—*Vauq.* It occurs in beds in porphyry, and various secondary trap rocks in Iceland and Tokay.

2. *Transparent.* Colour duck-blue. Massive and in brown grains. Splendent. Fracture perfect conchoidal. Perfectly transparent. Hard. Brittle. Sp. gr. 2.36. It melts more easily than the translucent obsidian, and into a white muddy glass. Its constituents are, silica 81, alumina 9.5, lime 0.33, oxide of iron 0.60, potash 2.7, soda 4.5, water 0.5.—*Klaproth.* It occurs imbedded in pearl-stone porphyry. It is found at Marekan, near Ochotsk in Siberia, and in the Serro de las Novajas in Mexico.*

* **OCHRE.** An ore of iron.*

* **OCHROITE.** Cerite.*

* **OCTOHEDRITE.** Pyramidal titanium-ore.*

* **OETITES.** Clay-ironstone.*

* **OIL OF VITRIOL.** See ACID (SULPHURIC).*

OIL. The distinctive characters of oil are inflammability, insolubility in water, and fluidity, at least in a moderate temperature. Oils are distinguished into fixed or fat oils, which do not rise in distillation at the temperature of boiling water; and volatile or essential oils, which do rise at that temperature with water, or under 320° by themselves.

The volatile oil obtained by attenuating animal oil, by a number of successive distillations, is called Dippel's animal oil.

Monnet asserts, that, by mixing acids with animal oil, their rectification may be very much facilitated.

The addition of a little ether, before redistillation of old essential oils, improves the flavour of the product. See ELAIN and ACID (OLEIC.)

* MM. Gay-Lussac and Thernard analyzed olive oil in 1808, by igniting a determinate quantity of it, mixed with chlorate of potash, and ascertaining the products; they found it to consist of

Carbon,	77.213
Hydrogen,	13.360
Oxygen,	9.427
	100.000

Or	Carbon,	77.213
ox. and hydr. in the proportions for forming water,		10.712
	Hydrogen excess,	12.075

If the pernitrate of mercury, made by dissolving 6 parts of mercury in 7.5 parts of nitric acid, of sp. gr. 1.36 at common temperatures, be mixed with olive oil, in the course of a few hours, the mixture, if kept cold, becomes solid; but if mixed with the oil of grains, it does not solidify. M. Pontet proposes therefore this substance as a test of the purity or adulteration of olive oil; for the resulting mixture, after standing 12 hours, is more or less solid, as the oil is more or less pure. The nature of the white, hard, and opaque mixture, formed by olive oil and the nitrate of mercury, has not been ascertained. See ACID MARGARIC, ELAIN, and FAT.*

* **OIL GAS.** It has been long known to chemists, that wax, oil, tallow, &c. when passed through ignited tubes, are resolved into combustible gaseous matter, which burns with a rich light. Messrs. Taylor and Martineau have availed themselves skilfully of this fact, and contrived an ingenious apparatus for generating oil gas on the great scale, as a substitute for candles, lamps, and coal gas. I shall insert here, a brief account of their improvements.

The advantages of oil gas, when contrasted with coal gas, are the following:—The material from which it is produced containing no sulphur or other matter by which the gas is contaminated, there are no objections to its use on account of the suffocating smell in close rooms. It does no sort of injury to furniture, books, plate, pictures, paint, &c. All the costly and offensive operation of purifying the gas by lime, &c. is totally avoided when it is obtained from oil. Nothing is contained in oil gas which can possibly injure the metal of which the conveyance pipes are made.

The economy of light from oil gas may be judged of from the following table:—

Argand burner oil gas, per hour,	¾*d.*
Argand lamps spermaceti oil, -	3*d.*
Mould candles, - - -	3½*d.*
Wax candles, - - -	14*d.*

The oil gas has a material advantage over coal gas, from its peculiar richness in olefiant gas, which renders so small volume necessary, that one cube foot of oil gas will be found to go as far as four of coal gas. This circumstance is of great importance, as it reduces in the same proportion the size of the gasometers, which are necessary to contain it: this is not only a great saving of expense in the construction, but it is a material convenience, where room is limitted.

In the course of their first experiments, Messrs. John and Philip Taylor were surprised to find, that the apparatus they employed gradually lost its power of decomposing oil, and generating gas. On investigation, they discovered that the metallic retorts which had originally decomposed oil and produced gas in abundance, ceased in a very great degree to possess this power, although no visible change had taken place in them.

The most perfect cleaning of the interior of the retort did not restore the effect, and some alteration appears to be produced on the iron by the action of the oil, at a high temperature.

Fortunately, the experiments on this subject led to a most favourable result; for it was found, that by introducing fragments of brick into the retorts, a great increase of the decomposing power was obtained, and the apparatus has been much improved by a circumstance which at one time appeared to threaten its success.

A small portion of the oil introduced into the retort, still passed off undecomposed, and being changed into a volatile oil, it carried with it a great portion of caloric, which rendered the construction of the apparatus more difficult than was at first anticipated; but by the present arrangement of its parts, this difficulty is fully provided for, and the volatilized oil is made to return into the oil reservoir, from whence it again passes into the retort, so that a total conversion of the whole into gas is accomplished without trouble, or the escape of any unpleasant smell.

A general idea of the process may be formed from the following account of it:—

A quantity of oil is placed in an air-tight vessel, in such a manner, that it may flow into retorts which are kept at a moderate red heat; and in such proportions as may regulate the production of gas to a convenient rate; and it is provided, that this rate may be easily governed at the will of the operator.

The oil, in its passage through the retorts, is principally decomposed, and converted into gas proper for illumination, having the great advantages of being pure and free from sulphurous contamination, and of supporting a very brilliant flame, with the expenditure of very small quantities.

As a further precaution to purify the gas from oil, which may be suspended in it in the state of vapour, it is conveyed into a wash vessel, where, by bubbling through water, it is further cooled and rendered fit for use; and passes by a proper pipe into a gasometer, from which it is suffered to branch off in pipes in the usual manner.

The oil gas which I have been accustomed to make has only a double illuminating power, compared to good coal gas.—See a drawing of an elegant apparatus, erected by Messrs. P. and M. at the Apothecaries' Hall, London, in the 15th number of the Journal of Science and the Arts.* †

* **Oisanite.** Pyramidal titanium-ore.*

* **Olefiant Gas.** A compound of one prime of carbon and one of hydrogen, to which I have given the name of Carburetted Hydrogen, to distinguish it from the gas resulting from one prime of carbon and two of hydrogen, which I have called subcarburetted hydrogen.*

* **Oleic Acid.** See Acid (Oleic).*

Oleosaccharum. This name is given to a mixture of oil and sugar, incorporated with each other, to render the oil more easily diffusible in watery liquors.

Oleum Vini. See Ether.

Olibanum. A gum-resin, the product of the Juniperus Lycia, *Linn.* brought from Turkey and the East Indies, usually in drops or tears. The best is of a yellowish-white colour, solid, hard, and brittle; when chewed for a little time, it renders the spittle white, and impresses an unpleasant bitterish taste; laid on burning coals, it yields an agreeable smell.

* **Olivenite.** An ore of copper.*

* **Olivine.** A sub-species of prismatic chrysolite. Its colour is olive-green. It occurs massive and in roundish pieces. Rarely crystallized in imbedded rectangular four-sided prisms. Lustre shining. Cleavage, imperfect double. Fracture, small-grained uneven. Translucent. Less hard than chrysolite. Brittle. Sp. gr. 3.24. With borax it melts into a dark green bead. It loses its colouring iron in nitric acid. Its constituents are, silica 50, magnesia 38.5, lime 0.25, oxide of iron 12. It occurs in basalt, greenstone, porphyry and lava, and generally accompanied with augite. It is found in the Lothians, Hebrides, north of Ireland, Iceland, France, Bohemia, &c.*

* **Ollaris Lapis.** See Potstone.*

* **Omphacite.** Colour pale leek-green. Massive, disseminated, and in narrow radiated concretions. Lustre, glistening and resinous. Fracture, fine-grained uneven. Feebly translucent. As hard as feldspar. Sp. gr. 3.3. It occurs in primitive rocks with precious garnet, in Carinthia. It is a variety of augite.*

* **Onyx.** Calcedony, in which there is an alternation of white, black, and dark-brown layers.*

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† I question the correctness of these statements concerning oil gas. On account of the sale of the coak, it has been found, even in this country, more profitable to make gas from coal than tar. Yet tar costs only about one-sixth of the price of the cheapest oil in our markets.

* **Opacity.** The faculty of obstructing the passage of light.*

* **Opal.** A sub-species of the indivisible quartz of Mohs.*

Of opal there are seven kinds, according to Professor Jameson.

1. *Precious opal.* Colour milk-white, inclining to blue. It exhibits a beautiful play of many colours. Massive, disseminated, in plates and veins. Lustre splendent. Fracture, perfect conchoidal. Translucent, or semi-transparent. Semi-hard in a high degree. Brittle. Uncommonly easily frangible. Sp. gr. 2.1. Before the blow-pipe it whitens and becomes opaque, but does not fuse. Its constituents are silica 90, water 10. It occurs in small veins in clay-porphyry, with semi-opal, at Czscherwenitza, in Upper Hungary; and in trap rocks, at Sandy Brae, in the north of Ireland. Some of them become transparent by immersion in water; and are called oculus mundi, hydrophane, or changeable opal.

2. *Common opal.* Colour milk-white. Massive, disseminated, and in angular pieces. Lustre splendent. Fracture perfect conchoidal. Semi-transparent. Scratches glass. Brittle. Adheres to the tongue. Infusible. Its constituents are, silica 93.5, oxide of iron 1, water 5.—*Klaproth.* It occurs in veins along with precious opal in clay-porphyry, and in metalliferous veins in Cornwall, Iceland, and the north of Ireland.

3. *Fire opal.* Colour hyacinth-red. Lustre splendent. In distinct concretions. Fracture perfect conchoidal. Completely transparent. Hard. Uncommonly easily frangible. Sp. gr. 2.12. Heat changes the colour to pale flesh-red. Its constituents are, silica 92, water 7.75, iron 0.25. It has been found only at Zimapan in Mexico, in a particular variety of hornstone porphyry.

4. *Mother-of-pearl opal,* or *Cacholong.* It is described under **Cacholong**, as a variety of calcedony.

5. *Semi-opal.* Colours white, gray, and brown; sometimes in spotted, striped, or clouded delineations. Massive, disseminated, and in imitative shapes. Lustre glistening. Fracture conchoidal. Translucent. Semi-hard. Rather easily frangible. Sp. gr. 2.0. Infusible. Its constituents are, silica 85, alumina 3, oxide of iron 1.75, carbon 5, ammoniacal water 8, bituminous oil 0.33.—*Klaproth.* It occurs in porphyry and amygdaloid, in Greenland, Iceland, and Scotland, in the Isle of Rume, &c.

6. *Jasper opal,* or *Ferruginous opal.* Colour scarlet-red, and gray. Massive. Lustre shining. Fracture perfect conchoidal. Opaque. Between hard and semi-hard. Easily frangible. Sp. gr. 2.0. Infusible. Its constituents are, silica 43.5, oxide of iron 47.0, water 7.5.—*Klaproth.* It is found porphyry at Tokay in Hungary.

7. *Wood opal.* Colours very various. In branched pieces and stems. Lustre shining. Fracture conchoidal. Translucent. Semi-hard in a high degree. Easily frangible. Sp. gr. 2.1. It is found in alluvial land at Zastravia in Hungary.*

* **Opium.** See **Morphia**, and **Acid** (**Meconic**). In the 8th and 9th volumes of the Journal of Science, and in the 1st of the Edinburgh Phil. Journal, are two valuable papers on the manufacture of British opium; the first by the Rev. G. Swayne, the second by Mr. Young. The manufacture of Indian opium has been of late years greatly improved by Dr. Fleming, M. P., under whose superintendence that important department was placed by the Marquis of Wellesley.*

According to Orfila, a dangerous dose of opium is rather aggravated than counteracted by vinegar. The proper remedy is a powerful emetic, such as sulphate of zinc, or sulphate of copper. See an interesting and well treated case, in the 1st volume of the Medico-Chirurgical Trans. by Dr. Marcet and Mr. Astley Cooper.*

Opobalsam. The most precious of the balsams is that commonly called Balm of Gilead, Opobalsamum, Balsamæleon, Balsamum verum album, Ægyptiacum, Judaicum, Syriacum, è Mecca, &c. This is the produce of the amyris opobalsamum, L.

The true balsam is of a pale yellowish colour, clear and transparent, about the consistence of Venice turpentine, of a strong, penetrating, agreeable, aromatic smell, and a slightly bitterish pungent taste. By age it becomes yellower, browner, and thicker, losing by degrees, like volatile oils, some of its finer and more subtile parts. To spread, when dropped into water, all over the surface, and to form a fine, thin, rainbow-coloured cuticle, so tenacious that it may be taken up entire by the point of a needle, were formerly infallible criteria of the genuine opobalsam. Neumann, however, had observed, that other balsams, when of a certain degree of consistence, exhibit these phenomena equally with the Egyptian. According to Bruce, if dropped on a woollen cloth, in its pure and fresh state, it may be washed out completely and readily with simple water.

Opodeldoc. A solution of soap in alcohol, with the addition of camphor, and volatile oils. It is used externally against rheumatic pains, sprains, bruises, and other like complaints.

Opopanax. A concrete gummy resinous juice, obtained from the roots of an umbelliferous plant, the pastinaca opopanax, *Linn.* which grows spontaneously in the warmer countries, and bears the colds of this. The juice is brought from Turkey and the East

etimes in round drops or tears,

monly in irregular lumps, of a

colour on the outside, with

specks of white; inwardly of a paler colour, and frequently variegated with large white pieces. It has a peculiar strong smell, and a bitter, acrid, somewhat nauseous taste.

* **Ores.** The mineral bodies, from which metals are extracted.

I.—**Antimony**, *Ores of.*

1. Native antimony, of which there are two species, dodecahedral, and octohedral.

1. *Dodecahedral.* Colour tin-white. Massive and crystallized in an octohedron and dodecahedron. Harder than calcareous spar. Sp. gr. 6.7. It consists of 98 antimony, 1.0 silver, and 0.25 iron. It is found in argentiferous veins in the gneiss mountains of Chalanches in Dauphiny, and at Andreasberg in the Hartz.

2. *Octohedral antimony;* of which there are two sub-species, the antimonial silver, and arsenical silver. See Ores of Silver.

II. **Antimony Glance.** Under this genus are ranged the following species, subspecies, and kinds.

1. *Compact gray antimony.* Colour light lead-gray. Massive. Soft. Easily frangible. Sp. gr. 4.4. Found in Huel Boys mine in Cornwall.

2. *Foliated gray antimony.* Colour like the preceding. Cleavage prismatic. Not particularly brittle. Sp. gr. 4.4.

3. *Radiated gray antimony.* Colour common lead-gray. Massive, and crystallized in four and six-sided prisms, and sometimes in acicular crystals. Lustre metallic. Sp. gr. 4.4. It melts by the flame of a candle. Its constituents are, antimony 75, sulphur 25. These minerals occur in veins, in primitive and transition mountains. This occurs in Glendinning in Dumfries-shire; in Cornwall, &c.

4. *Plumose gray antimony.* Colour between dark lead-gray and smoke-gray. Massive, and in capillary glistening crystals. Lustre semi-metallic. Very soft. It melts into a black slag. It contains antimony, sulphur, arsenic, iron, and silver. It occurs in veins in primitive rocks, at Andreasberg in the Hartz, &c.

5. *Axifrangible antimony glance,* or *Bournonite.* Colour blackish lead-gray. Massive and crystallized. Primitive form, an oblique four-sided prism, which occurs variously modified by truncation, &c. Lustre metallic. Cleavage axifrangible. Fracture conchoidal. Brittle. Sp. gr. 5.7. Its constituents are, lead 42.62, antimony 24.23, copper 12.8, iron 1.2, sulphur 17.—*Hatchett.* It is found near Endellion in Cornwall.

6. *Prismatic antimony glance.* Colour blackish lead-gray. Primitive form, an oblique four-sided prism. Lustre metallic. Cleavage in the direction of the smaller diagonal of the prism. Sp. gr. 5.75.

III. *Antimony ochre.* Colour straw-yellow, incrusting crystals of gray antimony. Dull. Fracture earthy. Very soft. Brittle. Whitens and evaporates before the blow-pipe. It occurs in veins in Saxony, &c.

IV. *Nickeliferous gray antimony.* Colour steel-gray. Massive. Shining. Cleavage double rectangular. Fragments cubical. Brittle. Sp. gr. 6. to 6.7. It melts before the blow-pipe, emitting white vapour of arsenic. It communicates a green colour to nitric acid. It consists of antimony, with arsenic 61.68, nickel 23.33, sulphur 14.16, silica, with silver and lead, 0.83, and a trace of iron. It occurs in veins near Freussberg in Nassau.

V. *Prismatic white antimony.* Colour white. Massive and crystallized, in a rectangular four-sided prism, an oblique four-sided prism, a rectangular four-sided table, a six-sided prism, and in acicular and capillary crystals. Lustre pearly or adamantine. Cleavage in the direction of the lateral planes. Translucent. Sectile. Sp. gr. 5.0 to 5.6. It melts and volatilizes in a white vapour. Its constituents are, oxide of antimony 86, oxides of antimony and iron 3, silica 8. It occurs in veins in primitive rocks, in Bohemia and Hungary.

VI. *Prismatic antimony-blende,* or *red antimony.*

a. Common. Colour cherry-red. Massive, in flakes, and crystallized. Primitive form, an oblique four-sided prism. Crystals delicate, capillary. Adamantine. Translucent on the edges. Brittle. Sp. gr. 4.5 to 4.6. It melts and evaporates before the blow-pipe. It consists of antimony 67.5, oxygen 10.8, sulphur 19.7.—*Klapr.* It occurs at Braunsdorf in Saxony.

b. Tinder antimony-blende. Colour muddy cherry-red. In flexible tinder like leaves. Feebly glimmering. Opaque. Streak shining. Friable. Sectile and flexible. It contains oxide of antimony 33, oxide of iron 40, oxide of lead 16, sulphur 4, with some silver.—*Link.* It occurs in the Carolina and Dorothea mines at Clausthal.

II.—**Arsenic.**

1. *Native arsenic.* Fresh fracture, whitish lead-gray. Massive, and in imitative shapes. Feebly glimmering. Harder than calcareous spar. Streak shining, metallic. When struck, it has a ringing sound, and emits an arsenical odour. Sp. gr. 5.75. It occurs in veins in primitive rocks, at Kongsberg in Norway, &c.

2. *Oxide of arsenic;* common, capillary, and earthy.

a. Common oxide has a white colour; occurs in crystalline crusts; has a shining lustre; uneven fracture; and is soft and semi-transparent.

b. The capillary occurs in silky, snow-white, shining, capillary crystals.

c. The earthy is yellowish-white; in crusts. Dull, opaque, and friable. It occurs at Andreasberg in the Hartz.

3. *Arsenical pyrites.*

a. *Common arsenical pyrites. Mispickel.* Fresh fracture silver-white. Massive and in prismatic concretions. Crystallized in oblique four-sided prisms. Lustre splendent metallic. Fracture coarse-grained. Cleavage in the direction of the perpendicular prism. Sometimes as hard as feldspar. Brittle. It emits an arsenical smell on friction. Sp. gr. 5.7 to 6.2. Before the blow-pipe it yields a copious arsenical vapour. Its constituents are, arsenic 43.4, iron 34.9, sulphur 20.1. It occurs in primitive rocks, in Cornwell and Devonshire, and at Alva in Stirlingshire.

b. *Argentiferous arsenical pyrites.* Colour silver-white. Disseminated, and in very small acicular oblique four-sided prisms. Shining and metallic. Besides arsenic and iron, it contains from 0.01 to 0.10 of silver, It has been found in Saxony; and is used as an ore of silver.

4. *Pharmacolite,* or *arsenic-bloom.* Colour reddish-white. As a coating of balls, or in delicate capillary shining silky crystals. Semi-transparent, or opaque. Soft. Soils. Sp. gr. 2.64. Its constituents are, lime 25 arsenic acid 50.44, water 24.56. It occurs in veins along with tin-white cobalt, at Andreasberg, &c.

5. *Orpiment.*

a. *Red, ruby sulphur,* or *hemi-prismatic sulphur* Colour aurora-red; massive; in flakes, and crystallized in oblique four-sided prisms. Lustre inclining to adamantine. Fracture uneven. Translucent. Streak orange-yellow coloured. As hard as talc. Brittle. Sp. gr. 3.35. It melts and burns with a blue flame. It is idio-electric by friction. Its constituents are, arsenic 69, sulphur 31. It occurs in primitive rocks at Andreasberg, &c.

b. *Yellow orpiment,* or *prismatoidal sulphur.* Colour perfect lemon-yellow. Massive, imitative, and crystallized in oblique four-sided prisms, and in flat double four-sided pyramids. Cleavage prismatoidal. Translucent. Harder than the red. Flexible, but not elastic. Splits easily. Sp. gr. 3.5. Its constituents are arsenic 62, sulphur 38. It occurs in veins in floetz rocks; and along with red silver in granite at Wittichen in Swabia.

III.—BISMUTH,

1. *Native* or *octohedral bismuth.* Fresh fracture silver-white, inclining to red. Massive and crystallized in an octohedron, tetrahedron, and cube. Lustre splendent, metallic. Cleavage fourfold. Harder than gypsum. Malleable. Sp. gr. 8.9 to 9.0. It melts by the flame of a candle. It occurs in veins in mica-slate, &c. at St. Columb and Botallack, in Cornwall; and in Saxony.

2. *Bismuth-glance.*

a. *Acicular bismuth-glance.* Colour dark lead-gray. Disseminated, and crystallized in oblique four or six-sided prisms. Lustre splendent, metallic. Fracture uneven. Opaque. Brittle. Sp. gr. 6.1 to 6.2. It fuses before the blow-pipe into a steel-gray globule. Its constituents are, bismuth 43.2, lead 24.32, copper 12.1, sulphur 11.58, nickel 1.58, tellurium 1.32, gold 0.79. It occurs imbedded in quartz near Beresof in Siberia. It is also called *needle ore.*

b. *Prismatic bismuth-glance.* Colour pale lead-gray. Massive, and crystallized in acicular and capillary oblique four and six-sided prisms. Lustre splendent, metallic. It soils; is brittle; and harder than gypsum. Sp. gr. 6.1 to 6.4. It melts in the flame of a candle. Its constituents are bismuth 60, sulphur 40. It occurs in veins in Cornwall, &c.

a. *Cupreous bismuth* Colour light lead-gray. Massive. Shining. Sectile. Its constituents are, bismuth 47.24, copper 34.66, sulphur 12.58. It occurs in veins in granite near Wittichen in Furstemberg.

b. *Bismuth ochre.* Colour straw-yellow. Massive. Lustre inclines to adamantine. Opaque. Soft. Brittle. Sp. gr. 4.37. It dissolves with effervescence in acids. Its constituents are, oxide of bismuth 86.3, oxide of iron 5.2, carbonic acid 4.1, water 3.4. It occurs along with red cobalt. It is found at St. Agnes in Cornwall.

IV.—CERIUM. See ALLANITE, CERITE, GADOLINITE, ORTHITE, YTTROCERITE. A fluate and subfluate of cerium have been also discovered at Finbo in Sweden.

V.—COBALT ORES.

1. *Hexahedral cobalt pyrites,* or *silver-white cobalt.* Colour silver-white. Massive, and crystallized in the cube, octohedron, cube truncated, pentagonal dodecahedron, icosahedron. Splendent, and metallic. Cleavage hexahedral. Fracture conchoidal. Semi-hard. Brittle. Streak gray. Sp. gr. 6.1 to 6.3. Before the blow-pipe, it gives out an arsenical odour; and, after being roasted, colours glass of borax smalt-blue. Its constituents are, cobalt 44, arsenic 55, sulphur 0.5. Iron is sometimes present. It occurs in primitive rocks at Skutterend, in Norway. It is the principal ore of cobalt.

2. *Octohedral cobalt pyrites.*

a. The *tin-white;* of which there is the compact and radiated. The *compact* has a tin-white, and sometimes rather dark colour. It occurs massive and crystallized in the cube, octohedron, and rhomboidal dodecahedron, truncated on the six four-edged angles Crystals generally rent and cracked. Lustre splendent, metallic. Brittle. Sp. gr. 6.0 to 6.6. Its constituents are, arsenic 74.22, cobalt 20.3, iron 3.42, copper 0.16, sulphur 0.89. It occurs in granite, gneiss, &c. in Cornwall, Saxony, &c.

The *radiated;* colour tin-white, inclining to gray. Massive, and in distinct radiated concretions. Lustre glistening, metallic. Softer than the compact. Its constituents are, arsenic 65.75, cobalt 28, oxide of iron

5.0. Oxide of manganese 1.25. It occurs in clay-slate at Schneeberg.

b. *Gray octohedral cobalt pyrites.* Colour light steel-gray. Massive, and tubiform. Dull, and tarnished externally. Internally splendent metallic. Fracture even. Streak shining. Brittle. When struck, emits an arsenical odour. Sp. gr. 6.135. It contains 19.6 of cobalt, with iron and arsenic. It occurs in granite, gneiss, &c. It is found in Cornwall, Norway, &c. It affords a more beautiful blue smalt than any of the other cobalt minerals.

Cobalt-kies. Colour pale steel-gray. Massive, and in cubes. Lustre metallic. Fracture uneven. Semi-hard. Its constituents are, cobalt 43.2, sulphur 38.5, copper 14.4, iron 3.53. It occurs in a bed of gneiss in Sweden.

3. *Red cobalt.*

a. *Radiated red cobalt,* or *cobalt bloom.* Colour crimson-red, passing into peach-blossom. Massive, imitative, and crystallized, in a rectangular four-sided prism, or a compressed acute double six-sided pyramid. Crystals acicular. Shining. Translucent. Rather sectile. Sp. gr. 4.0 to 4.3. It tinges borax glass-blue. Its constituents are, cobalt 39, arsenic acid 38, water 23. It occurs in veins in primitive, transition, and secondary rocks. It is found at Alva in Stirlingshire, in Cornwall, &c.

b. *Earthy red cobalt,* or *cobalt crust.* Colour, peach-blossom red. Massive, and imitative. Friable. Dull. Sectile. Streak shining. Does not soil.

c. *Slaggy red cobalt.* Colour muddy crimson-red. In crusts and reniform. Smooth. Shining. Fracture conchoidal. Translucent. Soft and brittle. It occurs at Furstemberg.

4. *Cobalt ochre.*

a. *Black.* The earthy-black has a dark brown colour; is friable, has a shining streak, and feels meagre. The indurated black has a bluish-black colour; occurs massive and imitative; has a glimmering lustre; fine earthy fracture; is opaque; soft; sectile; soils; sp. gr. 2. to 2.4. It consists of black oxide of cobalt, with arsenic and oxide of iron. These two sub-species occur usually together; in primitive or secondary mountains; at Alderly Edge, Cheshire, in red sandstone; at Howth, near Dublin, in slate-clay.

b. *Brown cobalt-ochre.* Colour liver-brown. Massive. Dull. Fracture, fine earthy. Opaque. Streak shining; soft, sectile, light. It consists of brown ochre of cobalt, arsenic, and oxide of iron. It occurs chiefly in secondary mountains. It is found at Kamsdorf, in Saxony.

c. *Yellow cobalt-ochre.* Colour muddy straw-yellow. Massive and incrusting. Rent. Dull. Fracture fine earthy. Streak shining. Soft and sectile. Sp. gr. 2.67, after absorbing water. It is the purest of the cobalt-ochres. It is found with the preceding. It contains silver.

5. *The sulphate of cobalt* is found at Biber, near Hannau, in Germany. It consists of sulphuric acid 19.74, oxide of cobalt 38.71, water 41.55. It has a light flesh-red colour; and a stalactitical form. Streak yellowish-white. Taste styptic.

VI.—COPPER ORES.

1. *Octohedral,* or *native copper.* Colour copper-red, frequently incrusted with green. Massive, imitative, and crystallized; in the perfect cube; the cube truncated, on the angles, on the edges, and on the edges and angles; the garnet dodecahedron; perfect octohedron; and rectangular four-sided prism. Lustre glimmering, metallic. Fracture hackly. Streak splendent, metallic. Harder than silver. Completely malleable. Flexible, but not elastic. Difficultly frangible. Sp. gr. 8.4 to 8.7. It consists of 99.8 of copper, with a trace of gold and iron. It occurs in veins, in granite, gneiss, &c. and is found chiefly in Cornwall.

2. *Octohedral red copper ore.*

a. *Foliated red copper ore.* Colour dark cochineal-red. Massive, and crystallized, in the perfect octohedron, which is the primitive form; in the octohedron, truncated on the angles; on the edges, with each angle acuminated with four planes; bevelled on the edges, and each angle acuminated with eight planes. Lustre adamantine, inclining to semi-metallic. Cleavage fourfold. Translucent on the edges, or translucent. Streak muddy tile-red. Hardness between calcareous and fluor spar. Brittle. Sp. gr. 5.6 to 6.0.

b. *Compact red copper ore.* Colour between lead-gray and cochineal-red. Massive and reniform. Lustre semi-metallic. Fracture even. Opaque. Streak tile-red. Brittle.

c. *Capillary red copper ore.* Colour carmine-red. In small capillary crystals. Lustre adamantine. Translucent.

The whole of these red ores are deutoxides of copper, and are easily reduced to the metallic state before the blow-pipe. They dissolve with effervescence when thrown in powder into nitric acid; and a green nitrate results. In muriatic acid no effervescence takes place. They occur principally in veins that traverse primitive and transition rocks; abundantly in the granite of Cornwall. The earthy red copper ore, which is rare, is a sub-species of the preceding.

d. *Tile ore.* The *earthy* tile ore has a hyacinth-red colour. It occurs massive and incrusting copper pyrites. It is composed of dull dusty particles. It soils slightly, and feels meagre. It occurs in veins, as at Lauterberg in the Hartz. The *indurated* tile ore has an imperfect flat conchoidal fracture; a streak feebly shining; and is intermediate between semi-hard and soft. It is an intimate combination of red copper ore and brown iron ochre, containing from 10 to 50 per cent of copper.

3. *Black copper*, or *black oxide of copper*. Colour between bluish and brownish-black. It occurs massive, and thinly coating copper pyrites. It is composed of dull dusty particles, which scarcely soil. Streak slightly shining. Before the blow-pipe it emits a sulphureous odour, melts into a slag, and communicates a green colour to borax. It is said to be an oxide of copper with oxide of iron. It occurs at Carharrack and Tincroft mines, in Cornwall.

4. *Emerald copper*, or *dioptase*. Colour emerald-green. It occurs only crystallized. The primitive form is a rhomboid of 123° 58′. The only secondary form at present known, is the equiangular six-sided prism. Lustre shining, pearly. Cleavage threefold. Fracture small conchoidal. Translucent. As hard as apatite. Brittle. Sp. gr. 3.3. It becomes a chesnut-brown before the blow-pipe, and tinges the flame green, but is infusible; with borax it gives a bead of copper. Its constituents are, oxide of copper 28.57, carbonate of lime 42.83, silica 28.57. —*Vauq*. By Lowitz, it consists of 55 oxide of copper, 33 silica, and 12 water, in 100. It is found in the land of Kirguise, 125 leagues from the Russian frontier, where it is associated with malachite and limestone.

5. *Blue copper, or prismatic malachite*, of which there are two kinds, the radiated and earthy.

The *radiated* has an azure-blue colour. Massive, imitative, and crystallized. Its primitive form is an oblique prism. The secondary forms are, an oblique four-sided prism, variously bevelled, and a rectangular four-sided prism, or eight-sided prism, acuminated with four planes. Lustre vitreous. Cleavage threefold. Fracture imperfect conchoidal. Translucent. Colour of the streak, lighter. Harder than calcareous spar. Brittle. Sp. gr. 3.65. It is soluble with effervescence in nitric acid. With borax it yields a metallic globule, and colours the flux green. Its constituents are, copper 56, carbonic acid 25, oxygen 12.5, water 6.5.—*Vauquelin*. It is found at Leadhills in Dumfries-shire, and Wanlockhead in Lanarkshire, and at Huel-Virgin and Carharrack in Cornwall, and in many places on the Continent.

b. Earthy blue copper. Colour smalt-blue. Massive. Friable. Sp. gr. 3.354. It is found in Norway, &c.

The velvet-blue copper belongs to the same species. Lustre glistening and pearly. It has been found only at Oravicza in the Bannat, along with malachite and the brown iron-stone.

6. *Malachite*; of which there are, the fibrous and compact.

a. *Fibrous malachite*. Colour perfect emerald-green. Imitative, and crystallized, in oblique four-sided prisms, variously bevelled or truncated; and in an acute-angular three-sided prism. Crystals short, capillary, and acicular. Lustre pearly or silky. Translucent, or opaque. Softer than blue copper. Streak pale green. Brittle. Sp. gr. 3.66. Before the blow-pipe it decrepitates, and becomes black. Its constituents are, copper 58, carbonic acid 18, oxygen 12.5, water 11.5.—*Klaproth*. It occurs principally in veins. It is found at Sandlodge in Mainland, one of the Shetlands; at Landidno in Caernarvonshire; and in the mines of Arendal in Norway.

b. *Compact malachite*. Colour emerald-green. Massive, imitative, and in four-sided prisms. Glimmering and silky. Fracture, small grained uneven. Opaque. Streak pale green. Sp. gr. 3.65. In veins, which traverse different rocks in Cornwall, Norway, &c. *Brown copper* from Hindostan is placed after this mineral by Professor Jameson. Its colour is dark blackish-brown. Massive, Soft. Sp. gr. 2.62. It effervesces in acids, letting fall a red powder. Its constituents are, carbonic acid 16.7, deutoxide of copper 60.75, deutoxide of iron 19.5, silica 2.1.—*Dr. Thomson*.

7. *Copper-green*.

Common copper-green, or *chrysocolla*, contains three sub-species.

a. *Conchoidal copper-green*. Colour verdigris-green. Massive, imitative, and incrusting. Glistening. Fracture conchoidal. Translucent. Harder than gypsum. Easily frangible. Sp. gr. 2.0 to 2.2. It becomes black and then brown before the blow-pipe, but does not fuse. It melts and yields a metallic globule with borax. Its constituents are, copper 40, oxygen 10, carbonic acid 7, water 17, silica 26.—*Klaproth*. It accompanies malachite. It is found in Cornwall, &c.

Siliceous copper, or *kieselkupfer*, is a variety of the above. Colour asparagus-green. In crusts. Glistening. Fracture even or earthy. Opaque. Soft. Its constituents are, copper 37.8, oxygen 8, water 21.8, silica 29, sulphate of iron 3.

b. *Earthy iron-shot copper-green*, Colour olive-green. Massive and in crusts. Friable. Opaque. Sectile.

c. *Slaggy iron-shot copper-green*. Colour blackish-green. Massive. Glistening. Fracture conchoidal. Opaque. Soft. Easily frangible. It is probably a compound of conchoidal copper-green and oxide of iron. Both occur together, and pass into each other. It occurs in Cornwall, along with olivenite.

8. *Prismatic vitriol, blue vitriol*, or *sulphate of copper*. Colour dark sky-blue. Massive imitative, and crystallized. The primitive figure is an oblique four-sided prism, in which the lateral edges are 124° 2′, and 55°

58′; with edges and angles often truncated. Shining. Cleavage double. Fracture conchoidal. Translucent. Harder than gypsum. Sp. gr. 2.1 to 2.2. Taste nauseous, bitter, and metallic. Its solution coats iron with metallic copper. Its constituents are, oxide of copper 32.13, sulphuric acid 31.57, water 36.3.—*Berzelius*. It occurs along with copper pyrites, in Parys-mine in Anglesea, and in Wicklow.

9. *Prismatic olivenite*, or *phosphate of copper*. Colour emerald-green. Massive, and in oblique four-sided prisms of 110°. Cleavage double oblique. Glistening. Fracture splintery. Opaque. Streak verdigris-green. As hard as apatite. Brittle. Sp. gr. 4, to 4.3. Fuses into a brownish globule. Its constituents are, oxide of copper 68.13, phosphoric acid 30.95, It is found at Virnebirg on the Rhine, along with quartz, red copper ore, &c.

10. *Di-prismatic olivenite*, or *lenticular copper*. Colour sky-blue. Massive, but generally crystallized. In very oblique four-sided prisms, bevelled; in rectangular double four-sided pyramids; shining; fracture uneven; translucent. Harder than gypsum. Brittle. Sp. gr. 2.85. Converted by the blow-pipe into a black friable scoria. Its constituents are, oxide of copper 49, arsenic acid 14, water 35.—*Chenevix*. Found in Cornwall.

11. *Acicular olivenite. a. Radiated or cupreous arseniate of iron.* Colour dark verdigris-green. Massive, imitative and in flat oblique four-sided prisms, acuminated or truncated. Lustre glistening pearly. Translucent on the edges. As hard as calcareous spar. Brittle. Sp. gr. 3.4.

b. Foliated acicular olivenite; arseniate of copper. Colour dark olive-green. In angulo-granular concretions, and in small crystals; which are oblique four-sided prisms; and acute double four-sided pyramids. Glistening. Fracture conchoidal. Translucent. Streak olive-green. As hard as calcareous spar. Brittle. Sp. gr. 4.2 to 4.6. It boils, and gives a hard reddish-brown scoria before the blow-pipe. Its constituents are, oxide of copper 60, arsenic acid 39.7.—*Chenevix*. In the copper mines of Cornwall.

c. Fibrous acicular olivenite. Colour olive-green. Massive, reniform, and in capillary and acicular oblique four-sided prisms. Glistening and pearly. Opaque. As hard as calc-spar. Brittle. Fibres sometimes flexible. Streak brown or yellow. Sp. gr. 4.1 to 4.2. Its constituents are, oxide of copper 50, arsenic acid 29, water 21. It occurs in Cornwall.

d. Earthy acicular olivenite. Colour olive-green. Massive and in crusts. Dull. Fracture fine earthy. Opaque. Very soft. It is found in Cornwall.

2. *Atacamite*, or *muriate of copper*.

a. Compact. Colour leek-green. Massive, and in short needle-shaped crystals which are oblique four-sided prisms, bevelled or truncated. Shining and pearly. Translucent on the edges. Soft. Brittle. Sp. gr. 4.4? It tinges the flame of the blow-pipe of a bright green and blue, muriatic acid rises in vapours, and a bead of copper remains on the charcoal. It dissolves without effervescence in nitric acid. Its constituents are, oxide of copper 73.0, water 16.9, muriatic acid 10.1.—*Klaproth*. It occurs in veins in Chili, and Saxony.

b. Arenaceous atacamite, or *copper-sand.* Colour grass-green. In glistening scaly particles. It does not soil. It is translucent. Its constituents are, oxide of copper 63, water 12, muriatic acid 10, carbonate of iron 1, mixed siliceous sand 11. It is found in the sand of the river Lipes, 200 leagues beyond Copiapu in the desert of Atacama, which separates Chili from Peru.

13. *Copper Pyrites.*

a. Octohedral copper pyrites. On the fresh fracture, its colour is brass-yellow; but it is usually tarnished. Massive, imitative and crystallized; in a regular octohedron, perfect, truncated or bevelled; and in a perfect or truncated tetrahedron. Glistening. Fracture uneven. Hardness from calcareous to fluor spar. Brittle. Sp. gr. 4.1 to 4.2. Before the blow-pipe, on charcoal, it decrepitates, emits a greenish-coloured sulphureous smoke, and melts into a black globule, which assumes metallic lustre. It tinges borax green. Its constituents are, copper 30, iron 53, sulphur 12.—*Chenevix*. It contains sometimes a little gold or silver. It occurs in all the great classes of rocks. It is found near Tynedrum in Perthshire; at the mines of Ecton: at Pary's mountain; abundantly in Cornwall; and in the county of Wicklow in Ireland. The rich ores are worked for copper; the poor, for sulphur.

b. Tetrahedral copper pyrites; of which species there are two sub-species, gray copper and black copper.

Gray-copper. Colour steel-gray. Massive and crystallized; in the tetrahedron, truncated or bevelled; and in the rhomboidal dodecahedron. Splendent. Fracture uneven. Hardness as calcareous spar and fluor. Brittle. Sp, gr. 4.4 to 4.9. Its constituents are, copper 41, iron 22.5, sulphur 10, arsenic 24.1, silver 0.4.—*Klaproth*. It occurs in beds and veins in Cornwall, and many other places.

Black copper. Colour iron-black. Massive and crystallized; in the tetrahedron, perfect, bevelled, or truncated. Splendent. Fracture conchoidal. Brittle. Sp. gr. 4.85. Its constituents are, copper 39, antimony 19.5, sulphur 26, iron 7.5, mercury 6.25.—*Klaproth*. The mercury is accidental. It occurs in veins in the Hartz, and in Peru.

14. *White copper*. Colour between silver-

white, and brass-yellow. Massive and disseminated. Glistening and metallic. Fracture uneven. Semi-hard. Brittle. Sp. gr. 4,5. It yields before the blow-pipe a white arsenical vapour, and melts into a grayish-black slag. It contains 40 per cent of copper; the rest being iron, arsenic and sulphur. It occurs in primitive and transition rocks. It is found in Cornwall and Saxony.

15. *Copper-glance*, or *vitreous copper*.

Rhomboidal copper-glance

§ 1. Compact. Colour, blackish lead-gray. Massive, in plates and crystallized. Primitive form, a rhomboid. Secondary forms; a low equiangular six-sided prism, and a double six-sided pyramid. Glistening, metallic. Harder than gypsum. Perfectly sectile. Rather easily frangible. Sp. gr. 5.5 to 5.8. Its constituents are, copper 78.05, iron 2.25, sulphur 18.5, silica 0.75.—*Klaproth.*

§ 2. *Foliated.* Its constituents are, copper 79.5, sulphur 19, iron 0.75, quartz 1.—*Ullmann.* It occurs in primitive rocks. It is found also in transition rocks, at Fassney-burn in East Lothian; in Ayrshire; at Middleton Tyas in Yorkshire; in Cornwall, &c.

16. *Variegated copper.* Colour, between copper-red and pinchbeck-brown. Massive, in plates, and crystallized in six-sided prisms. Glistening, metallic. Soft. Easily frangible. Specific gravity, 5. It is fusible, but not so easily as copper-glance, into a globule, which acts powerfully on the magnetic needle. Its constituents are, copper 69.5, sulphur 19, iron 7.5, oxygen 4.—*Klaproth.* It occurs in gneiss, mica-slate, &c. It is found in Cornwall.

VII.—GOLD ORES.

1. *Hexahedral*, or *native gold*.

a. Gold-yellow native gold. Colour, perfect gold-yellow. Disseminated, in grains, and crystallized; in the octohedron, perfect or truncated; in the cubo-octohedron; in the cube, perfect or truncated; in the double eight-sided pyramid; in the tetrahedron, and rhomboidal dodecahedron. Splendent. Fracture, fine hackly. Soft. Difficultly frangible. Malleable. Sp. gr. from 17 to 19, and so low as 12. Fusible into a globule. It is gold with a very minute portion of silver and copper. It occurs in many very different rocks; and in almost every country. See an extensive enumeration of localities, in Jameson's Mineralogy.

b. Brass-yellow native gold, occurs capillary; in octohedrons, and in six-sided tables. Specific gravity, 12.713. Its constituents are, gold 96.9, silver 2, iron 1.1. It is found in the gold mines of Hungary, in Siberia, &c.

c. Grayish-yellow native gold. Colour brass-yellow verging on steel-gray. In small flattish grains. Never crystallized. It is said to contain platina. It is rather denser than the last. It occurs along with platina and magnetic iron-ore in South America.

d. Argentiferous gold, or *electrum.* Colour, pale brass-yellow. In small plates, and imperfect cubes. Its constituents are, 64 gold, 36 silver. It occurs along with massive heavy spar in Siberia. Klaproth says, it is acted on neither by nitric nor nitro-muriatic acid. See TELLURIUM ORES.

VIII.—IRIDIUM ORE. Colour, pale steel-gray. In very small irregular flat grains. Lustre shining and metallic. Fracture foliated. Brittle. Harder than platina. Sp. gr. 19.5. By fusion with nitre, it acquires a dull black colour, but recovers its original colour and lustre, by heating with charcoal. It consists of iridium, with a portion of osmium. It occurs in alluvial soil in South America, along with platina.—*Wollaston.*

IX.—IRON ORE.

I. *Native*, or *octohedral iron*.

a. Terrestrial native iron. Colour, steel-gray. Massive, in plates and leaves. Glistening, and metallic. Fracture hackly. Opaque. Malleable. Hard. Magnetic. Its constituents are, iron 92.5, lead 6, copper 1.5.—*Klaproth.* It is found with brown iron-stone and quartz in a vein, in the mountain of Oulle, in the vicinity of Grenoble, &c.

6. *Meteoric native iron.* Colour, pale steel-gray, inclining to silver-white. Generally covered with a thin brownish crust of oxide of iron. It occurs ramose, imperfect globular, and disseminated in meteoric stones. Surface, smooth and glistening. Internally, it is intermediate between glimmering and glistening, and the lustre is metallic. Fracture hackly. Fragments blunt-edged. Yields a splendent streak. Intermediate between soft and semi-hard. Malleable. Flexible, but not elastic. Very difficultly frangible. Sp. gr. 7.575. Its constituents are,

	Agram.	*Arctic.*	*Mexico.*	*Siberian.*
Iron,	96.5	97	96.75	90.54
Nickel,	3.5	3	3.25	9.46
	100.0	100	100.00	100.00
	Klapr.	*Brande.*	*Klapr.*	*Children.*

The American native iron contains 0.10 of nickel; the Siberian 0.17; and the Senegambian 0.05 and 0.06.—*Howard.* It appears to be formed in the atmosphere, by some process hitherto unknown to us. See METEOROLITE, and *Jameson's Mineralogy*, iii. p. 101.

II. *Iron-ore.*

a. Octohedral iron-ore, of which there are three kinds.

§ 1. *Common magnetic iron-ore.* Colour, iron-black. Massive, in granular concretions, and crystallized: in the octohedron, truncated, bevelled and cuneiform; rhomboidal dodecahedron; rectangular four-sided prism; cube; tetrahedron; equiangular six-sided table; and twin crystal. Splendent, and metallic. Cleavage fourfold. Fracture uneven. Streak black. Harder than apatite. Brittle. Specific gravity, 4.8

to 5.2. Highly magnetic, with polarity. Before the blow-pipe it becomes brown, and does not melt; it gives glass of borax a dark green colour. Its constituents are, peroxide of iron 69, protoxide of iron 31.—*Berzelius.* It occurs in beds of great magnitude, in primitive rocks, at Unst; at St. Just in Cornwall; at Arendal in Norway, &c. It affords excellent bar-iron.

§ 2. *Granular magnetic iron-ore,* or *iron-sand.* Colour very dark iron-black. In small grains and octohedral crystals. Glimmering. Fracture conchoidal. Brittle. Streak black. Sp. gr. 4.6 to 4.8. Magnetical with polarity. Its constituents are oxide of iron 85.5, oxide of titanium 14, oxide of manganese 0.5.—*Klaproth.* It occurs imbedded in basalt, &c. It is found in Fifeshire, in the Isle of Skye, in the river Dee in Aberdeenshire, &c.

§ 3. *Earthy magnetic iron-ore.* Colour bluish-black. In blunt-edged rolled pieces. Dull. Fracture, fine grained uneven. Opaque. Soft. Streak black, shining. Soils. Sectile. It emits a faint clayey smell when breathed on. Sp. gr. 2.2. It occurs in the iron mines of Arendal in Norway.

b. Rhomboidal iron-ore; of which there are three sub-species.

§ 1. *Specular iron-ore, iron-glance,* or *fer oligiste of the French.* Of this there are two kinds, the common and micaceous. *Common specular iron-ore.* Colour dark steel-gray. Massive, disseminated, and crystallized. Prim. form; a rhomboid, or double three-sided pyramid, in which the angles are 87° 9′ and 92° 51′. The secondary figures are, the primitive form variously bevelled, truncated and acuminated; the flat rhomboid; equiangular six-sided table; low equiangular six-sided prism; and very acute six-sided pyramid. Lustre, splendent metallic. Cleavage threefold. Fracture imperfect conchoidal. Streak cherry-red. Hardness, between feldspar and quartz. Rather difficultly frangible. Sp. gr. 5.2. Magnetic in a slight degree. Its constituents are, reddish-brown oxide of iron 94.38, phosphate of lime 2.75, magnesia 0.16, mineral oil? 1.25.—*Hisinger.* It occurs in beds in primitive mountains. It is found at Cumberhead in Lanarkshire; at Norberg in Westmannland, in Norway, &c. It affords an excellent malleable iron.

Micaceous specular iron-ore. Colour iron-black. Massive, disseminated and in small thin six-sided tables, intersecting one another so as to form cells. Splendent, metallic. Cleavage, single curved-foliated. Translucent in thin plates. Streak cherry-red. As hard as the above. Most easily frangible. Sp. gr. 5.07. It slightly affects the magnet. It is peroxide of iron. It occurs in beds in mica-slate. It is found at Dunkeld, and Benmore in Perthshire; in several parts of England and Norway, &c. The iron it affords is sometimes cold short, but is well fitted for cast ware. It is characterized by its high degree of lustre, openness of its cleavage, and easy frangibility. It affords from 70 to 80 per cent. of iron.

§ 2. *Red iron-ore;* of which there are four kinds, the scaly, ochry, compact, and fibrous.

Scaly red iron-ore, or *red iron froth.* Colour dark steel-gray, to brownish-red. Friable, and consists of semi-metallic shining scaly parts, which are sometimes translucent and soil strongly. Its constituents are, iron 66, oxygen 28.5, silica 4.25, alumina 1.25.—*Henry.* But Bucholz found it to be a pure red oxide of iron, mixed with a little quartz sand. It occurs in veins in primitive rocks. It is found at Ulverstone in Lancashire; in Norway, &c.

Ochry red iron-ore, or *red ochre.* Colour brownish-red. Friable. Dusty dull particles. Soils. Streak, blood-red. Easily frangible. Sp. gr. 2.947. It occurs in veins, with the preceding ore. It melts more easily than any of the other ores of this metal, and affords excellent malleable iron.

Compact red iron-ore. Colour between dark steel-gray and blood-red. Massive, and in supposititious crystals; which are an acute double six-sided pyramid from calcareous spar; and a cube from fluor spar and iron pyrites. Lustre metallic. Fracture even. Streak pale blood-red. Easily frangible. Sp. gr. 4.232. When pure it does not affect the magnet. Its constituents are oxide of iron 70.5? oxygen 29.5?—*Bucholz.* It occurs in beds and veins in gneiss, &c. It affords good bar and cast-iron.

Fibrous red iron-ore, or *red hematite.* Colour between brownish-red and dark steel-gray. Massive, imitative, and in supposititious double six-sided pyramids from calcareous spar. Glistening, semi-metallic. Opaque. Streak blood-red. Brittle. Sp. gr. 4.74. Its constituents are, 90 oxide of iron, silica 2, lime 1, water 3.—*Daubuisson.* It occurs with the compact. It affords excellent malleable and cast-iron. Its powder is used for polishing tin, silver, and gold vessels; and for colouring iron brown.

§ 3. *Red clay iron-ore,* or *stone;* of which the varieties are, the ochry, the columnar, the lenticular, and jaspery. The first is used for red crayons: and is called red-chalk. It occurs in Hessia, &c. The second consists of 50 oxide of iron, 13 water, 32 silica, and 7 alumina.—*Brocchi.* It is rare, and is called a pseudo-volcanic product. The third affords excellent iron. It consists of oxide of iron 64, alumina 23, silica 7.5, water 5. The jaspery is found in Austria.

c. Prismatic iron-ore, or *brown iron-stone.* Of this we have four sub-species.

§ 1. *Ochry brown iron-ore.* Yellowish,

brown; massive; dull; fracture, earthy; soils; soft; sectile. Its constituents are, peroxide of iron 83, water 12, silica 5. It occurs with the following.

§ 2. *Compact.* Colour passes to clove-brown. Massive, and in supposititious crystals from pyrites. Dull. Brittle. Sp. gr. 3 to 3.7. It contains 84 peroxide of iron, 11 water, and 2 silica. It affords about 50 per cent. of good bar iron.

§ 3. *Fibrous.* Clove-brown. Imitative; and in supposititious crystals. Splendent externally. Glimmering internally. Opaque. Harder than apatite. Brittle. Sp. gr. 3.9. Streak pale yellowish-brown. Its constituents are, 80.25 oxide of iron, 15 water, 3.75 silica.—*Vauquelin.*

The preceding sub-species occur most frequently in transition and secondary mountains. They are found in veins in sandstone, along with heavy spar, at Cumberhead in Lanarkshire, &c. They melt easily, and afford from 40 to 60 per cent of good bar, but indifferent cast-iron. Good steel may be made from it.

§ 4. *Brown clay iron-ore;* of which there are five kinds, the common, the pisiform, the reniform, the granular, and umber.

The *first* occurs massive; has a flat conchoidal fracture; a brown streak; and is soft. It contains 69 oxide of iron, 3 manganese, 13 water, 10 silica, and 3 alumina. The *second* has a yellowish-brown colour. It occurs in small solid spherical grains, composed of concentric concretions. Sp. gr. 3.142. It consists of 48 oxide of iron, 31 alumina, 15 silica, and 6 water.—*Vauquelin.* It is found in hollows in shell limestone, at Galston in Ayrshire, &c. It yields from 40 to 50 per cent of iron: and in Dalmatia it is used as small shot. The *third* has a yellowish-brown colour. Massive, and imitative; in concentric lamellar concretions, which often include a loose nodule. Glimmering. Sectile. Its constituents are, peroxide of iron 76, water 14, silica 5, oxide of manganese 2. It occurs in iron-shot clay in secondary rocks. It is found in East and Mid Lothian, in Colebrookdale, &c. It yields an excellent iron. The *fourth,* or granular, occurs massive and in grains. Fracture thick slaty. Streak yellowish-brown. Soft. Brittle. Sp. gr. 3. It occurs in beds between the red limestone of the salt formation, and the lias limestone. It is found in Bavaria, France, &c. It affords about 40 per cent of good iron. *Fifth, Umber.* Colour clove-brown. Massive. Dull. Fracture, flat conchoidal. Soft. Sectile. Soils strongly. Feels meagre. Adheres strongly to the tongue, and readily falls to pieces in water. Sp. gr. 2.06. It consists of oxide of iron 48, oxide of manganese 20, silica 13, alumina 5, water 14.—*Klaproth.* It occurs in beds in the Island of Cyprus. It is used as a pigment.

Bog iron-ore is arranged as a variety of the above. There are three kinds of it.

§ 1. *Meadow ore,* or *friable bog iron-ore.* Colour pale yellowish-brown. Friable. Dull. Fracture, earthy. Soils. It feels meagre, but fine.

§ 2. *Swamp ore,* or *indurated bog iron-ore.* Colour dark yellowish-brown. Corroded and vesicular. Dull. Earthy. Very soft. Sectile. Sp. gr. 2.944.

§ 3. *Meadow ore,* or *conchoidal bog iron-ore.* Blackish-brown. Massive, and tuberose. Glistening. Fracture small conchoidal. Streak yellowish-gray. Soft. Sp. gr. 2.6. Its constituents are, oxide of iron 66, oxide of manganese 1.5, phosphoric acid 8, water 23.—*Klaproth.* By Vauquelin's experiments it seems to contain also chrome, magnesia, silica, alumina, and lime; zinc and lead are likewise occasionally present. It belongs to a recent formation; Werner's ingenious theory of which is given by Professor Jameson, vol. xiii. p. 247. It is found in the Highlands of Scotland, in Saxony, &c. The second is most easily reduced, and affords the best iron.

Pitchy iron-ore may also be placed here. Its colour is blackish-brown. Massive. Glistening. Fracture flat conchoidal. Translucent on the edges. Hard. Streak yellowish-gray. Brittle. Sp. gr. 3.562. Its constituents are, phosphoric acid 27, manganese 42, oxide of iron 31.—*Vauquelin.* It occurs near Limoges in France.

Iron sinter. Colour brown. Massive and imitative. Glistening. Fracture flat conchoidal. Translucent. Soft. Brittle. Sp. gr. 2.4. Its constituents are, water 25, oxide of iron 67, sulphuric acid 8.—*Klaproth.* It occurs in the galleries of old mines in Saxony and Silesia.

III. *Iron pyrites.*

§ 1. *Hexahedral,* or *common iron pyrites.* Colour perfect bronze-yellow. Massive, imitative, and crystallized; in cubes, variously bevelled. Lustre from specular-splendent, to glistening, and metallic. Cleavage, hexahedral. Fracture uneven. Harder than feldspar, but softer than quartz. Brittle. When rubbed it emits a strong sulphureous smell. Sp. gr. 4.7 to 5. It burns with a bluish flame, and sulphureous odour before the blow-pipe. It afterwards changes into a brownish-coloured globule, which is attractible by the magnet. Its constituents are, sulphur 52.5, iron 47.5.—*Hatchett.* Silver and gold are occasionally present. It occurs in beds in various mountains. It is worked for sulphur or copperas.

§ 2. *Prismatic iron pyrites.*

a. Radiated pyrites. Colour pale bronze-yellow. Most usually imitative, or crystallized. Primitive form is an oblique four-sided prism, in which the obtuse angle is 106° 36′. Secondary forms are the above variously bevelled; and the wedge-shaped double four-sided pyramid. Harder than feldspar. Sp. gr. 4.7 to 5.0. Its constituents are, sulphur 53.6, iron 46.4.—*Hatchett.* It is much rarer than the preceding. It is found in Cornwall, Isle of Sheppy, &c.

b Hepatic, or *liver pyrites*. Colour pale brass-yellow. Massive and imitative. Glimmering and metallic. Fracture even. Sp. gr. 4.834. It occurs in veins in primitive rocks. It is found in Derbyshire, &c.

c. Cellular pyrites. Colour bronze-yellow. Cellular. Surface of the cells drusy. Fracture flat conchoidal. It occurs in veins at Johanngeorgenstadt in Saxony.

d. Spear pyrites. Colour between bronze-yellow and steel-gray. Crystallized in twin or triple crystals. Fracture uneven. It occurs in veins in primitive rocks, associated with brown coal.

d. Cockscomb pyrites. Colour as above. Crystallized in double four-sided pyramids. Glistening and metallic. It occurs in Derbyshire.

§ 3. *Rhomboidal iron pyrites*, or *magnetic pyrites*.

a. Foliated magnetic. Colour between bronze-yellow and copper-red. Massive, and sometimes crystallized, in a regular six-sided prism, truncated; and in a six-sided pyramid. Splendent and metallic. Sp. gr. 4.4 to 4.6. It occurs in Saxony.

b. Compact magnetic. Same colour. Massive. It affects the magnetic needle. Its constituents are, sulphur 36.5, iron 63.5.—*Hatchett*. It is found in Galloway and Caernarvonshire.

IV. *Native salts of iron*.

a. The *Prismatic chrome-ore*. Colour between steel-gray and iron-black. Massive, and in oblique four-sided prisms, acuminated with four planes. Lustre imperfect metallic. Fracture small grained uneven. Opaque. Hardness, between apatite and feldspar. Streak dark brown. Sp. gr. 4.4 to 4.5. Some varieties are magnetic, others not. It is infusible before the blow-pipe. With borax, it forms a beautiful green-coloured mass. The constituents of the French are, oxide of iron 34.7, oxide of chrome 43, alumina 20.3, silica 2.—*Haüy*. The Siberian contains 34 oxide of iron, 53 oxide of chrome, 11 alumina, 1 silica, and 1 manganese.—*Laugier*. It occurs in primitive serpentine. It is found in the islands of Unst and Fetlar, in Scotland; and also at Portsoy in Banffshire. In considerable quantity in serpentine on the Bare-hills near Baltimore.

b Sparry iron, or *carbonate of iron*. Colour pale yellowish-gray. Massive, disseminated, and crystallized. The primitive form is a rhomboid of 107°. The following are some of the secondary forms:—the primitive rhomboid, perfect or truncated; a still flatter rhomboid; the spherical lenticular form; the saddle-shaped lens; the equiangular six-sided prism. Glistening and pearly. Cleavage threefold. Fracture foliated. Translucent on the edges, or opaque. Streak white or yellowish-brown. Harder than calcareous spar. Sp. gr. 3.6 to 3.9. It blackens, and becomes magnetic before the blow-pipe. It effervesces with muriatic acid. Its constituents are, oxide of iron 57.5, carbonic acid 36, oxide of manganese 3.5, lime 1.25.—*Klaproth*. It occurs in veins in granite, and in limestone. In small quantities in Britain. In great quantity at Schmalkalden in Hessia. It affords an iron well suited for making steel.

c. Rhomboidal vitriol, or *green vitriol*. Colour emerald-green. Primitive form of the crystals is a rhomboid, with edges of 81° 23′ and 98° 37′; and plane angles of 100° 10′ and 79° 50′. Vitreous or pearly lustre. Cleavage threefold. Fracture flat conchoidal. Semi-transparent. Refracts double. As hard as gypsum. Sp. gr. 1.9 to 2.0. Taste sweetish, styptic, and metallic. Before the blow-pipe, on charcoal, it becomes magnetic. Its constituents are, oxide of iron 25.7, sulphuric acid 28.9, water 45.4.—*Berzelius*. It results from the decomposition of iron pyrites.

d. Arseniate of iron. See CUBE ORE.

e. Blue iron, or *phosphate of iron*.

Prismatic blue iron.

§ 1. *Foliated blue iron*. Colour dark indigo-blue. Primitive form an oblique four-sided prism. The secondary forms are, a broad rectangular four-sided prism, truncated; and an eight-sided prism. Shining. Cleavage straight, single. Translucent. As hard as gypsum. Streak, paler blue. Sectile, and easily frangible. Flexible in thin pieces. Sp. gr. 2.8 to 3.0. Its constituents are, oxide of iron 41.25, phosphoric acid 19.25, water 31.25, iron-shot silica 1.25, alumina 5.—*Fourcroy* and *Laugier*. It occurs in St. Agnes's in Cornwall.

§ 2. *Fibrous blue iron*. Colour indigo-blue. Massive, and in delicate fibrous concretions. Glimmering and silky. Opaque. Soft. It occurs in syenite at Stavern in Norway.

§ 3. *Earthy blue iron*. Colour as above. Friable, and in dusty particles. Soils slightly. Rather light. Before the blow-pipe it loses its blue colour, becomes reddish-brown, and lastly, melts into a black coloured slag, attractible by the magnet. Its constituents are, oxide of iron 47, phosphoric acid 32, water 20.—*Klaproth*. It occurs in nests in clay-beds. In several of the Shetland islands, and in river mud at Toxteth, near Liverpool.

4. *Tungstate of iron*. See ORES of TUNGSTEN.

5. *Blue ironstone*. Colour indigo-blue. Massive, and with impressions of crystals of brown iron ore. Glimmering, or dull. Fracture coarse grained uneven. Opaque.

Semi-hard. Rather brittle. Sp. gr. 3.2.—*Klaproth.* It loses its colour by heat; and with borax forms a clear bead. Its constituents are, oxide of iron 40.5, silica 50, lime 1.5, natron 6, water 3. It occurs on the banks of the Orange River in Southern Africa.

X.—Lead Ores.

1. *Galena* or *lead-glance.*

Hexahedral galena.

§ 1. *Common.* Colour fresh lead-gray. Massive, imitative, and crystallized in cubes, octohedrons, rectangular four-sided prisms, broad unequiangular six-sided prisms, six-sided tables, and three-sided tables. Specular splendent, to glimmering. Lustre metallic. Cleavage hexahedral. Fragments cubical. Harder than gypsum. Sectile and frangible. Sp. gr. 7. to 7.6. Before the blow-pipe it flies in pieces, then melts, emitting a sulphureous odour, while a globule of lead remains. Its constituents are, lead 83, sulphur 16.41, silver 0.08.—*Westrumb.* It occurs in beds, &c. in various mountain rocks. At Leadhills in Lanarkshire, &c. Nearly all the lead of commerce is obtained from galena. The ore is roasted and then reduced with turf.

§ 2. *Compact galena.* Colour somewhat darker than the preceding. Massive, shining, metallic. Fracture flat conchoidal. Streak more brilliant. It consists of sulphuret of lead, sulphuret of antimony, and a small portion of silver. It is found at Leadhills in Lanarkshire, in Derbyshire, &c.

§ 3. *Friable galena.* Colour dark fresh lead-gray. Massive and in thick flakes. Sectile. It is found only around Freyberg.

Blue lead. Colour between very dark indigo-blue and dark lead-gray. Massive, and crystallized in regular six sided prisms. Feebly glimmering. Soft. Sectile. Sp. gr. 5.461. It is conjectured to be sulphuret of lead, intermixed with phosphate of lead. It occurs in veins. It has been found in Saxony and France.

Cobaltic galena. Colour fresh lead-gray. Minutely disseminating in exceedingly small crystals, aggregated in a moss-like form. Shining and metallic. Scaly foliated. Opaque. Soft. Soils feebly. It communicates a smalt-blue colour to glass of borax. It occurs near Clausthal in the Hartz.

2. *Lead spar.*

§ 1. *Tri-prismatic lead spar*, or *sulphate of lead.* Colours yellowish and grayish-white. Massive and crystallized. In the primitive form the vertical prism is 120°. The principal crystallizations are, an oblique four-sided prism, variously bevelled or truncated; and a broad rectangular four-sided pyramid. Lustre shining, adamantine. Fracture conchoidal. Translucent. As hard as calcareous spar. Streak white. Brittle. Sp. gr. 6.3. It decrepitates before the blow-pipe, then melts, and is soon reduced to the metallic state. Its constituents are, oxide of lead 70.5, sulphuric acid 25.75, water 2.25. —*Klaproth.* It occurs in veins along with galena at Wanlockhead in Dumfries-shire, Leadhills, Pary's mine, and Penzance.

§ 2. *Pyramidal lead spar, or yellow lead spar.* Colour wax-yellow. Massive, cellular, and crystallized. Its primitive form is a pyramid, in which the angles are 99° 40′ and 131° 45′. Its secondary forms are, the pyramid variously truncated, on the angles and summits, and a regular eight-sided table. Lustre resinous. Cleavage fourfold. Fracture uneven. Translucent. As hard as calcareous spar. Brittle. Sp. gr. 6.5 to 6.8.—*Mohs.* (5.706, *Hatchett*). Its constituents are, oxide of lead 58.4, molybdic acid 38, oxide of iron 2.08, silica 0.28.—*Hatchett.* It occurs at Bleiberg in Carinthia.

§ 3. *Prismatic lead spar*, or *red lead spar.* Colour hyacinth-red. Crystallized, in long slightly oblique four-sided prisms, variously bevelled, acuminated or truncated. Splendent, adamantine. Fracture uneven. Translucent. Streak between lemon-yellow and orange-yellow. Harder than gypsum. Sectile. Easily frangible. Sp. gr. 6.0 to 6.1. Before the blow-pipe it crackles and melts into a gray slag. It does not effervesce with acids. Its constituents are, oxide of lead 63.96, chromic acid 36.4.—*Vauquelin.* It occurs in veins in gneiss in the gold mines of Beresofsk in Siberia.

§ 4. *Rhomboidal lead spar.*

a. Green lead spar. Colour, grass-green. Imitative or crystallized. The primitive form is a di-rhomboid, or a flat equiangular double six-sided pyramid. The secondary forms are, the equiangular six-sided prism, variously truncated and acuminated. Splendent. Fracture uneven. Translucent. Sometimes as hard as fluor. Brittle. Sp. gr. 6.9 to 7.2. It dissolves in acids without effervescence. Its constituents are, oxide of lead 80, phosphoric acid 18, muriatic acid 1.62, oxide of iron, a trace.—*Klaproth.* It occurs along with galena at Leadhills, and Wanlockhead; at Alston in Cumberland, &c.

b. Brown lead spar. Colour, clove-brown. Massive and crystallized; in an equiangular six-sided prism; and an acute double three-sided pyramid. Glistening, resinous. Feebly translucent. Streak grayish-white. Brittle. Sp. gr. 6.91. It melts before the blow-pipe, and during cooling, shoots into acicular crystals. It dissolves without effervescence in nitric acid. Its constituents are, oxide of lead 78.58, phosphoric acid 19.73, muriatic acid 1.65. It occurs in veins that traverse gneiss. It is found at Miess in Bohemia.

§ 5. *Di-prismatic lead spar.*

a. White lead spar. Carbonate of lead. Colour, white. Massive and crystallized; in a very oblique four-sided prism; an unequiangular six sided prism; acute double six-sided pyramid; oblique double four-sided pyramid; long acicular crystals; and in twin and triple crystals. Lustre, adamantine. Fracture small conchoidal. Translucent. Refracts double in a high degree. Harder than calcareous spar. Brittle. Sp. gr. 6.2 to 6.6. It dissolves with effervescence in muriatic and nitric acids. It yields a metallic globule with the blow-pipe. Its constituents are, oxide of lead 82, carbonic acid 16, water 2.—*Klaproth.* It occurs in veins at Leadhills in Lanarkshire.

b. Black lead spar. Colour, grayish-black. Massive, cellular and seldom crystallized, in very small six-sided prisms. Splendent, metallo-adamantine. Fracture uneven. Streak whitish-gray. Its constituents are, oxide of lead 79, carbonic acid 18, carbon 2.—*Lampadius.* It occurs in the upper part of veins, at Leadhills, &c.

c. Earthy lead spar. Colour, yellowish-gray. Massive. Glimmering. Opaque. Streak, brown. Very soft. Sp. gr. 5.579. Its constituents are, oxide of lead 66, carbonic acid 12, water 2.25, silica 10.5, alumina 4.75, iron and oxide of manganese 2.25. —*John.* It is found at Wanlockhead.

Corneous lead ore, or *muriate of lead.* Colour, grayish-white. Crystallized, in an oblique four-sided prism, variously truncated, bevelled, and acuminated. Splendent and adamantine. Cleavage threefold. Fracture conchoidal. Transparent. Soft. Sectile and easily frangible. Sp. gr. 6.065. It melts into an orange-coloured globule. Its constituents are, oxide of lead 85.5, muriatic acid 8.5, carbonic acid 6.—*Klaproth.* It is found in Cromford-level near Matlock in Derbyshire.

Arseniate of lead.

§ 1. *Reniform.* Colour reddish-brown. Shining. Fracture conchoidal. Opaque. Soft and brittle. Sp. gr. 3.933. It gives out arsenical vapours with the blow-pipe. It colours glass of borax lemon-yellow. Its constituents are, oxide of lead 35, arsenic acid 25, water 10, oxide of iron 14, silver 1.15, silica 7, alumina 2. It is found in Siberia.

§ 2. *Filamentous.* Colours, green or yellow. In acicular six-sided prisms, or in silky fibres. Slightly flexible and easily frangable Sp. gr. 5.0 to 6.4. Its constituents are, oxide of lead 69.76, arsenic acid 26.4, muriatic acid 1.58.—*Gregor.* It occurs in Cornwall.

§ 3. *Earthy arseniate.* Colour, yellow. In crusts. Friable. It occurs at St. Prix in France.

Native minium. Colour scarlet-red. Massive, amorphous, and pulverulent. It is found in Grassington-moor, Craven. Mr. Smithson thinks this mineral is produced by the decay of galena or lead-glance.

XI.—Manganese Ores.

1. *Prismatic manganese ore.*

§ 1. *Gray manganese ore.*

a. Fibrous gray manganese ore. Colour, dark steel-gray. Massive, imitative, and in very delicate acicular crystals, and in thin and long rectangular four-sided tables. Shining and splendent. Soils strongly. Soft. Brittle. It occurs in the Westerwald.

b. Radiated. Colour, dark steel-gray. Massive, imitative, and crystallized. The primitive form is an oblique four-sided prism, in which the largest angle is about 100°. Secondary forms are, the primitive bevelled, or acuminated, or spicular crystals. Cleavage prismatic. Streak dull black. Soils. Soft. Brittle. Sp. gr. 4.4 to 4.8. Shining and metallic. Its constituents are, black oxide of manganese 90.5, oxygen 2.25, water 7.—*Klaproth.* It occurs in the vicinity of Aberdeen, in Cornwall, Devonshire, &c.

c. Foliated. Colour between steel-gray and iron-black Massive and crystallized in short oblique four-sided prisms. Shining, metallic. Cleavage prismatic. Fracture uneven. Other characters, as above. Sp. gr. 3.742. It is found in Devonshire.

d. Compact. Fracture even, or flat conchoidal. Sp. gr. 4. to 4.4. Other characters as preceding. Its constituents are, yellow oxide of manganese? 50, oxygen 33, barytes 14, silica 1 to 6. *Analysis doubtful.* It occurs at Upton Pyne in Devonshire.

e. Earthy. Friable. It consists of semi-metallic feebly glimmering fine scaly particles, which soil strongly. It occurs in the mine Johannis in the Erzegebirge. It tinges borax purple; and effervesces with muriatic acid, giving out chlorine. These five kinds occur in granite, gneiss, &c. either in veins or in large cotemporaneous masses.

§ 2. *Black manganese ore.*

a. Compact. Colour, between bluish-black and steel-gray. Massive, imitative, and in curved lamellar concretions. Glimmering and imperfect metallic lustre. Fracture conchoidal. Streak shining, with colour unchanged. Semi-hard. Brittle. Sp. gr. 4.75.

b. Fibrous. Massive, imitative, and in delicate scopiform concretions. Fragments cuneiform and splintery. Its other characters as above. It yields a violet-blue glass with borax. It occurs in veins in the Erzegebirge. It yields a good iron; but acts very powerfully on the sides of the furnace. It is called black hematite.

c. Foliated. Colour brownish-black. Crystallized sometimes in acute double four-sided pyramids. Shining. Cleavage single, and curved foliated. Streak dark reddish-brown. Brittle. It is supposed to consist of iron and manganese.

§ 3. *Scaly brown manganese ore.* Colour between steel-gray and clove-brown. In crusts. Massive and imitative. Friable. Composed of shining scaly particles. Soils strongly. Feels greasy. It gives to glass of borax, an olive-green colour. It occurs in drusy cavities in brown hematite. It is found near Sandlodge in Mainland, one of the Shetlands.

4. *Manganese-blende.*

Prismatic. Colour, iron-black. Massive, in distinct concretions, and sometimes crystallized. Primitive form, an oblique four-sided prism, which becomes variously modified by truncations on the lateral edges. Lustre splendent, and semi-metallic. Streak greenish. Harder than calcareous spar. Easily frangible. Before the blow-pipe it gives out sulphur, and tinges borax violet-blue. Its constituents are, oxide of manganese 82, sulphur 11.5, carbonic acid 5.—*Klaproth.* Oxide of manganese 85, sulphur 15.—*Vauquelin.* It is found in Cornwall.

5. *Phosphate of manganese.* Colour, brownish-black. Massive and disseminated. Glistening. Fracture flat conchoidal. Semi-transparent, in splinters. Scratches glass. Streak yellowish-gray. Brittle. Sp. gr. 3.5 to 3.7. It is fusible into a black enamel. Its constituents are, oxide of manganese 42, oxide of iron 31, phosphoric acid 27. It occurs in a coarse granular granite at Limoges in France.

6. *Rhomboidal red manganese.*

a. Foliated. Colour, bright rose-red. Massive, imitative, and crystallized in rhomboids. Shining, pearly. Cleavage rhomboidal. Translucent on the edges. Hardness between fluor and calcareous spar. Brittle. Sp. gr. 3.3 to 3.6. Before the blow-pipe it first becomes dark brown, and then melts into a reddish-brown bead. Its constituents are, oxide of manganese 52.6, silica 39.6, oxide of iron 4.6, lime 1.5, volatile ingredients 2.75.—*Berzelius.* It occurs in beds of specular iron ore in gneiss hills in Sweden and Siberia. The specimens of the latter are cut into ornamental stones.

b. Fibrous. Colours, rose-red and flesh-red. Massive and in distinct prismatic fibrous concretions. Glistening and pearly. Fragments splintery. Feebly translucent. It occurs in Transylvania and Hungary.

c. Compact. Colour, pale rose-red. Massive or reniform. Glimmering. Sp. gr. 3.3 to 3.9. Its constituents are, oxide of manganese 61, silica 30, oxide of iron 5, alumina 2.—*Lampad.* It occurs at Kapnik in Transylvania.

Pitchy iron ore may be regarded as a phosphate of manganese.

XII. MERCURY ORES.

1. *Native mercury.*

a. Fluid mercury. See MERCURY. It occurs principally in rocks of the coal formation, associated with cinnabar, corneous mercury, &c. Small veins of it are rarely met with in primitive rocks, accompanied with native silver, &c. It is found at Idria, in the Friaul; Niderslana in Upper Hungary; in the Palatinate; Deux-Ponts, &c.

b. Dodecahedral mercury, or *native amalgam.*

§ 1. *Fluid,* or *semi-fluid amalgam.* Colour tin-white. In roundish portions; and crystallized, in a rhomboidal dodecahedron, rarely perfect. Splendent. When cut, it emits a creaking sound. As hard as talc. Sp. gr. 10.5. Its constituents are, mercury 74, silver 25. It is found at Deux-Ponts.

§ 2. *Solid amalgam.* Colour, silver-white. Massive and disseminated. Fracture flat conchoidal. As hard as gypsum. Brittle. Creaks strongly when cut. Sp. gr. 10.5. The mercury flies off before the blow-pipe. Its constituents are, mercury 74, silver 25.—*Heyer.* Mercury 64, silver 36.—*Klaproth.* It is found in Hungary, the Deux-Ponts, &c.

2. *Cinnabar,* or *prismato-rhomboidal ruby-blende.*

a. Dark red cinnabar. Colour cochineal-red. Massive, disseminated, imitative, and crystallized. Primitive form a rhomboid. Secondary forms; a regular six-sided prism, an acute rhomboid and a six-sided table. Splendent, adamantine. Translucent. Streak scarlet-red, shining. Harder than gypsum. Sectile and easily frangible. Sp. gr. 6.7 to 8.2. It melts, and is volatilized with a blue flame, and sulphureous odour. Its constituents are, mercury 84.5, sulphur 14.75.—*Klaproth.*

b. Bright red cinnabar. Colour bright scarlet-red. Massive, and in delicate fibrous concretions. Glimmering and pearly. Fracture earthy. Opaque. Streak, shining. Soils. Friable. It occurs in rocks of clay-slate, talc-slate, and chlorite-slate; in veins at Horzowitz in Bohemia; at Idria, &c.

c. Hepatic cinnabar.

§ 1. *Compact.* Colour between cochineal-red and dark lead-gray. Massive. Glimmering and semi-metallic. Streak shining. Opaque. Soft. Sectile. Sp. gr. 7.2. Its constituents are, mercury 81.8, sulphur 13.75, carbon 2.3, silica 0.65, alumina 0.55, oxide of iron 0.2, copper 0.02, water 0.73.

§ 2. *Slaty mercurial hepatic ore.* Colour as above, but sometimes approaching to black. Massive, and in roundish concretions. Lustre shining, semi-metallic. Fracture curved slaty. Most easily frangible. Streak cochineal-red, inclining to brown. Rather lighter than the compact. It occurs in considerable masses in slate-clay and bituminous shale. It is most abundant in Idria.

3. *Corneous mercury,* or *horn quicksilver.*

Pyramidal corneous mercury. Colour ash-gray. Vesicular, with interior crystallizations; which are, a rectangular four-sided prism, variously acuminated, and a double four-sided pyramid. Crystals very minute. Shining, adamantine. Cleavage single. Faintly translucent. Soft. Sectile and easily frangible. It is totally volatilized before the blow-pipe, with a garlic smell. It is soluble in water, and the solution mixed with lime-water, gives an orange-coloured precipitate. Its constituents are, oxide of mercury 76, muriatic acid 16.4, sulphuric acid 7.6—*Klaproth.* It occurs in Bohemia, &c.

XIII.—MOLYBDENA ORES.

Rhomboidal molybdena. Colour fresh lead-gray. Massive, in plates, and sometimes crystallized. Primitive form is a rhomboid. Secondary figures are, a regular six-sided table, and a very short six-sided prism, flatly acuminated on both extremities. Splendent, metallic. Cleavage single. Opaque. Streak on paper, bluish-gray; on porcelain, greenish-gray. Soils slightly. Harder than talc. Easily frangible. Splits easily. In thin leaves flexible, but not elastic. Sectile, approaching to malleable. Feels greasy. Sp. gr. 4.4 to 4.6. It emits a sulphureous odour before the blow-pipe. It is soluble, with violent effervescence, in carbonate of soda. Its constituents are, molybdena 60, sulphur 40.—*Bucholz.* It occurs disseminated in granite, gneiss, &c. It is found in Glenelg in Inverness-shire, at Peterhead, at Corybuy at the head of Loch Creran, in Cornwall, &c.

Molybdena ochre. Colour sulphur-yellow. Disseminated and incrusting molybdena. Friable; dull. In Corybuy and Norway.

For *molybdate of lead,* see LEAD ORES.

XIV.—NICKEL ORES.

1. *Native nickel.* Colour brass-yellow. In delicate capillary crystals. Shining and metallic. Crystals rigid. Brittle. It consists, according to Klaproth, of nickel, with a small quantity of cobalt and arsenic. It occurs in veins is gneiss, in Saxony.

2. *Nickel pyrites,* or *copper nickel.*

Prismatic nickel pyrites. Colour copper-red, becoming black. Massive, disseminated, imitative, and crystallized, in oblique four-sided prisms. Shining, metallic. Harder than apatite. Rather difficultly frangible. Sp. gr. 7.5 to 7.7. It emits an arsenical vapour before the blow-pipe, and then fuses into a dark scoria, mixed with metallic grains. It yields a dark green solution with nitro-muriatic acid. Its constituents are nickel and arsenic, with accidental admixtures of cobalt, iron, and sulphur. It generally occurs in primitive rocks. It is found in small quantities at Leadhills and Wanlockhead, and in the coal field of Linlithgowshire.

Black nickel. Colour dark grayish-black. Massive, and in crusts. Dull. Earthy fracture. Soft. Streak shining. Soils slightly. It forms an apple-green coloured solution with nitric acid, which lets fall a white precipitate with arsenic acid. It occurs in veins that traverse bituminous marl-slate at Riegelsdorf.

Nickel ochre. Colour apple-green. In an efflorescence. Dull. Fracture splintery. Soft. Feels meagre. It gives to glass of borax a hyacinth-red colour. It occurs at Leadhills, at Alva in Stirlingshire, and in Saxony. It consists of oxide of nickel 67, oxide of iron 23.2, water 1.5, loss 8.3.—*Lampadius.*

XV.—PALLADIUM ORE.

Native palladium. Colour pale steel-gray, passing into silver-white. It occurs in small grains. Lustre metallic. Fracture diverging fibrous. Opaque. Sp. gr. 11.8 to 12.148. It is infusible, but on the addition of sulphur, it melts. It forms a deep red solution with nitric acid. It consists of palladium, alloyed with a minute portion of platina and iridium. It is found in grains along with grains of native platina, in the alluvial gold districts in Brazil.—*Wollaston.*

XVI.—PLATINA ORE. Colour very light steel-gray. In flat small grains. Shining and metallic. Nearly as hard as iron. Malleable. Sp. gr. 17.7. It is found in the gray silver ore of Guadalcanal in Spain, in Choco, in New Granada, and in the province of Barbacoas. It is peculiar to an alluvial tract of 600 leagues, where it is associated with grains of native gold, zircon, spinel, quartz, and magnetic ironstone. It is not true, that this metal occurs near Carthagena, or Santa Fé, or in the islands of Porto Rico and Barbadoes, or in Peru, although these different localities are mentioned by authors. The *gray copper ore* of Guadalcanal in Spain contains from 1 to 10 per cent. of platina.

XVII.—SILVER ORES.

1. *Hexahedral,* or *native silver.*

a. Common native silver. Colour pure silver-white. Disseminated, in plates or membranes, imitative, and crystallized; in a cube; octohedron; tetrahedron; rhomboidal dodecahedron; leucite form; and six-sided table. Crystals microscopic. Shining and metallic. Fracture fine hackly. Streak splendent. Harder than gold, tin, lead; but softer than iron, platina, and copper. Perfectly malleable. Flexible, and difficultly frangible. Sp. gr. 10 to 10.4. Its constituents are, metallic silver 99, metallic antimony 1, with a trace of copper and arsenic. —*John.* It occurs principally in veins in primitive mountains. In granite in the Erzegebirge. In gneiss and mica-slate in Saxony, Bohemia, and Norway. In clay-slate in Ireland. In clay-porphyry at Alva, in the Ochil Hills, Stirlingshire. For a copious list of localities, see *Jameson's Mineralogy.*

b. Ariferous native silver. Colour between brass-yellow and silver-white. Disseminated, in membranes, and crystallized in cubes. Its sp. gr. is greater than that of the preceding. Its constituents are, silver 72, gold 28.—*Fordyce.* It occurs in veins in primitive rocks at Kongsberg in Norway.

2. *Silver-glance,* or *vitreous silver.*

§ 1. *Hexhahedral.*

a. Compact. Colour dark blackish lead-gray. Massive, imitative, and crystallized; in a cube, octohedron, rhomboidal dodecahedron, and double eight-sided pyramid. Glistening, metallic. Cleavage rhomboidal. Harder than gypsum. Completely malleable. Flexible, but not elastic. Difficultly frangible. Sp. gr. 5.7 to 6.1. Before the blow-pipe it loses its sulphur, and a bead of pure silver remains. Its constituents are, silver 85, sulphur 15.—*Klaproth.* It is one of the most frequent of the ores of silver. It occurs in mica-slate, clay-slate, graywacke, and seldomer in granite. It is found in Cornwall.

b. Earthy. Colour bluish-black. In crusts. Friable or solid. Dull. Feebly translucent. Streak shining, metallic. Soils a little. Easily frangible. Sectile. It is easily fused by the blow-pipe. It is a sulphuret of silver.

§ 2. *Rhomboidal silver-glance.* Colour between iron-black and blackish lead-gray. Crystallized. Primitive form, a rhomboid. Secondary figures; an equiangular six-sided prism, an equiangular six-sided table, and a double six-sided pyramid. The tabular crystals often intersect each other, forming cells. Highly splendent, and metallic. Soft. Sectile, Easily frangible. Sp. gr. 5.7 to 6.1. It melts with difficulty. Its constituents are silver 66.5, sulphur 12, antimony 10, iron 5, copper and arsenic 0.5, earthy substances 1.0. It occurs in gneiss, &c. It is found in the district of Freyberg.

3. *White silver.* Colour very light lead-gray. Massive, disseminated, and always associated with lead-glance. Glistening and metallic. Fracture even. Soft. Sectile. Easily frangible. Sp. gr. 5.3 to 5.6. Before the blow-pipe it melts and partly evaporates, leaving a bead of impure silver, surrounded by a yellow powder. Its constituents are, lead 41, silver 9.25, antimony 21.5, iron 1.75, sulphur 22, alumina 1, silica 0,75.—*Klaproth.* It occurs in gneiss. It is found near Freyberg.

4. *Gray silver* or *carbonate of silver.* Colour ash-gray. Massive and disseminated. Glistening. Fracture uneven. Soft. Streak more shining. Brittle. Heavy. Easily reduced before the blow-pipe. Its constituents are, silver 72.5, carbonic acid 12, oxide of antimony, and a trace of copper 15.5.—*Selb.* It occurs in veins that traverse granite in the Black Forest.

5. *Antimonial silver.* Colour, between silver-white and tin-white. Massive, disseminated, in distinct concretions, and crystallized; in a rectangular four-sided prism, in an unequiangular six-sided prism, and a double six-sided pyramid, truncated on the apices. Surface of the prisms, longitudinally streaked. Splendent, metallic. Cleavage, octohedral. Hardness, between calc and fluor spar. Sp. gr. 9.4 to 10. The antimony is volatilized before the blow-pipe, and silver remains on the charcoal. Its constituents are, silver 78, antimony 22.—*Vauquelin.* It occurs in veins in granite, and graywacke. In the first, at Altwolfach in Suabia; in clay-slate in the Hartz. See DODECAHEDRAL ANTIMONY.

6. *Arsenical silver.* Colour on the fresh surface, tin-white, which tarnishes grayish-black. Massive, and reniform. Fracture small-grained uneven. Harder than antimonial silver. Streak shining. Sectile, and easily frangible. Sp. gr. 9.44. Before the blow-pipe the antimony and arsenic are volatilized with a garlic smell; while a globule of silver remains, which is more or less pure. Its constituents are, arsenic 35, iron 44.25, silver 12.75, antimony 4. It generally occurs along with native arsenic. It is found in the Hartz.

7. *Bismuthic silver.* Colour pale lead-gray. Disseminated, and rarely crystallized in capillary crystals. Glistening and metallic. Soft. Sectile. Easily frangible. Its constituents are, bismuth 27, lead 33, silver 15, iron 4.3, copper 0.9, sulphur 16.3.—*Klaproth.* It has been found only in the Friedrich-Christian Mine in the Black Forest, in veins, in gneiss.

8. *Ruby-blende.*

§ 1. *Rhomboidal ruby-blende.*

a. Dark red silver. Colour between cochineal-red, and dark lead-gray. Massive, in membranes, and crystallized. Prim. form, a rhomboid of 109° 28′. Secondary forms, an equiangular six-sided prism, variously truncated and acuminated; and an equiangular double six-sided pyramid. Splendent and adamantine. Cleavage rhomboidal. Semi-transparent. Streak cochineal-red. Harder than gypsum. Sectile. Easily frangible. Sp. gr. 5.2 to 5.7. Before the blow-pipe, it first decrepitates, then melts with a slight effervescence, leaving a globule of silver. Its constituents are, silver 60, antimony 20.3, sulphur 14.7, oxygen 5.—*Klaproth.* It occurs in veins in gneiss, &c. It is found in the silver mines of Kongsberg, and in those of the Hartz.

§ 2. *Light red silver.* Colour cochineal-red. Streak aurora-red, passing into cochineal-red. Sp. gr. 5.5 to 5.9. In other respects, as preceding. Its constituents are, silver 54.27, antimony 16.3, sulphur 17.75, oxygen 11.85.—*Vauquelin.* It occurs at Andreasberg in the Hartz.

XVIII.—TANTALUM ORES.

1. *Prismatic tantalum ore. Columbite of Hatchett.* Colours grayish and brownish-black. Massive, disseminated, and crystallized in oblique four-sided prisms. Semi-metallic adamantine lustre. Fracture coarse-grained uneven. Opaque. As hard as feldspar. Difficultly frangible. Sp. gr. 6.0 to 6.3. It does not fuse with glass of borax. Its constituents are,

	Wollaston.	
oxide of tantalum,	85	80
oxide of iron,	10	15
oxide of manganese,	4	5
	Finland.	N. American, or Columbite.

It occurs in a coarse red granite in Finland, and in Massachusett's Bay, in North America.

2. *Yttrotantalite.* Colours iron-black and yellowish-brown. Imbedded in angular pieces, and crystallized in oblique four-sided and in six-sided prisms. Resinous, metallic lustre. Fracture conchoidal. Opaque. Scratches glass. Streak gray-coloured. Easily frangible. Sp. gr. 5.4 to 5.88. It decrepitates, but does not fuse with the blow-pipe. Its constituents are, oxide of tantalum 57, yttria 20.25, lime 6.25, oxide of iron 3.5, oxide of uranium 0.5, tungstic acid 8.25. It occurs along with gadolinite in a bed of flesh-red feldspar in gneiss at Ytterby in Sweden.

XIX.—Tellurium Ores.

1. *Hexahedral* or *native tellurium.* Colour tin-white. Massive, disseminated, and in rectangular four-sided prisms, acuminated with four planes. Shining, metallic. Cleavage hexahedral. As hard as gypsum. Rather brittle. Sp. gr. 6.1 to 6.2. It melts as easily as lead, emits a thick white smoke, and burns with a light green colour, and a pungent acrid odour, like that of horse-radish. Its constituents are, tellurium 92.55, iron 7.2, gold 0.25. It occurs in veins in graywacke, at Fatzebay, in Transylvania, and in Norway.

2. *Prismatic black tellurium.* Colour between blackish lead-gray and iron-black. Massive, in flakes, and crystallized. Primitive figure, an oblique four-sided prism. Secondary forms are, an oblique four-sided table, a six-sided table, an eight-sided table, and an acute double four-sided pyramid. Splendent and metallic. Fragments tabular. Harder than talc. Sectile. Soils slightly. The thin leaves and tables are flexible. Sp. gr. 7.0 to 7.2. It melts very easily before the blow-pipe. Its constituents are tellurium 32.2, lead 54, gold 9, sulphur 3, copper 1.3, silver 0.5.—*Klaproth.* It is worked for the gold it contains. It is found at Naygag, in Transylvania.

3. *Prismatic gold glance.*

§ 1. *Graphic gold glance,* or *tellurium.* Colour steel-gray. Massive, in leaves and crystallized. Primitive form, an oblique four-sided prism. Splendent, metallic. Cleavage prismatic. Fracture fine-grained uneven. As hard as gypsum. Brittle. Soils slightly. Sp. gr. 5.7 to 5.8. Before the blow-pipe it burns with a green flame, and is volatilized. Its constituents are, tellurium 60, gold 30, silver 10. It occurs in porphyry in Transylvania.

§ 2. *Yellow gold glance,* or *yellow tellurium.* Colour silver-white, inclining to brass-yellow. Disseminated and crystallized, in four-sided acicular prisms, which are rare. Splendent, metallic. Cleavage prismatic. Fracture small-grained uneven. Sp. gr. 5.7 to 5.8. Its constituents are, tellurium 44.75, gold 26.75, lead 19.5, silver 8.5, sulphur 0.5.—*Klaproth.* It occurs in veins in porphyry at Naygag, in Transylvania.

XX.—Tin Ores.

1. *Pyramidal tin ore.*

§ 1. *Common tin ore,* or *tinstone.* Colour blackish-brown. Massive, disseminated, but most frequently crystallized. Primitive form, a double four-sided pyramid, in which the angles are 133° 36′ and 67° 42′. Secondary figures are, the primitive truncated; a rectangular four-sided prism, variously truncated or acuminated, and twin crystals. Splendent, and adamantine. Fracture uneven. From semi-transparent to opaque. Streak grayish-white. As hard as feldspar, sometimes as quartz. Easily frangible. Sp. gr. 6.3 to 7.0. Before the blow-pipe it decrepitates, and becomes paler, and is reduced to the metallic state. Its constituents are, tin 77.5, iron 0.25, oxygen 21.5, silica 0.75 It occurs in granite, gneiss, &c.; and in an alluvial form, in what are in Cornwall called *stream works.* There are only three tin districts in Europe; Cornwall, which is the most considerable; the Erzegebirge; and Monte Rey, in Gallicia.

§ 2. *Cornish tin ore,* or *wood-tin.* Colour hair-brown. In rolled and imitative shapes. Glistening. Opaque. Softer than common tinstone. Streak gray, inclining to brown Brittle. Sp. gr. 6.4. Its constituents are, oxide of tin 91, oxide of iron 9.—*Vauquelin.* It occurs along with stream-tin.

2. *Tin pyrites.* Colour between steel-gray and brass-yellow. Massive and disseminated. Glistening and metallic. Fracture uneven. Yields easily to the knife. Brittle. Sp. gr. 4.35. Not magnetic. Before the blow-pipe it exhales a sulphureous vapour, and melts easily. Its constituents are, tin 34, copper 36, iron 3, sulphur 25, earthy matter 2.—*Klaproth.* It has been found only in Cornwall, in granite, at St. Michael's Mount.

XXI.—Titanium Ores.

1. *Prismatic titanium ore,* or *sphene.*

a. Common sphene. Colours, reddish, yellowish, and reddish-brown. It occurs in granular concretions, and crystallized in the following forms: A low very oblique four-sided prism, bevelled or truncated; a broad six-sided prism; a rectangular four-sided prism; an oblique double four-sided pyramid. Shining and adamantine. Fracture imperfect conchoidal. Streak grayish or yellowish-white. Harder than apatite. Brittle. Sp. gr. 3.4 to 3.6. Before the blow-pipe it is fusible with difficulty into a brownish-black enamel. Its constituents are, oxide of titanium 46, silica 36, lime 16, water 1.—*Klaproth.* It occurs in the syenite of Criffle, and other hills in Galloway; in the syenite of Inveraray; on the south side of Loch-Ness; the granite of Aberdeen; the syenite of Culloden, in Inverness-shire; in the floetz rocks of Mid-Lothian; and at Arendal, in Norway.

b. *Foliated sphene.* Colour yellow. Massive, in straight lamellar concretions, and crystallized as the preceding. Lustre splendent. Cleavage double. Fracture imperfect conchoidal. Translucent. It occurs at La Portia, in Piedmont, St. Gothard, and Arendal.

2. *Prismato-pyramidal titanium ore.*

a. *Rutile.* Colour reddish-brown. Massive and crystallized. Primitive figure, a pyramid of 117° 2′ and 84° 48′. Secondary forms are, a long rectangular four-sided prism; four-sided prism; six-sided prism; and acicular crystals. The crystals are occasionally curved. Splendent or glistening. Streak brown. Translucent. Harder than apatite. Brittle. Sp. gr. 4.255.—*Lowry.* It is pure oxide of titanium, with a little oxide of iron. It occurs in the granite of Cairngorm, the limestone of Rannoch, and in the rocks of Ben Gloe, where it was discovered by Dr. M'Culloch.

b. *Iserine.* Colour iron-black. In obtuse angular grains, and in rolled pieces. Splendent and metallic. Fracture conchoidal. Harder than feldspar. Opaque. Brittle. Sp. gr. 4.6. Before the blow-pipe it melts into a blackish-brown coloured glass, which is slightly attracted by the magnet. Its constituents are, oxide of titanium 28, oxide of iron 72.—*Klaproth;* or oxide of titanium 48, oxide of iron 48, oxide of uranium 2.—*Thomson.* It occurs imbedded in gneiss, and disseminated in granite sand, along with iron sand, in the bed of the river Don, in Aberdeenshire.

c. *Menachanite.* Colour grayish-black. In small flattish angular grains. Glimmering or semi-metallic. Opaque. Brittle. Sp. gr. 4.427. It is attractible by the magnet. Its constituents are, oxide of iron 51, oxide of titanium 45.25, oxide of manganese 0.25, silica 3.5.—*Klaproth.* It is found in the valley of Manachan in Cornwall.

3. *Pyramidal titanium ore,* or *octohedrite.* Colour passes from indigo-blue to brown. Crystallized. Its primitive form is a pyramid of 97° 38′ and 137° 10′. The following are secondary figures; the pyramid truncated on the extremities, and double four-sided pyramid, variously acuminated. Lustre splendent, adamantine. Cleavage fourfold. Translucent. Harder than apatite. Brittle. Sp. gr. 3.8 to 3.9. It is oxide of titanium. It is found in Dauphiny.

XXII.—Tungsten Ores.

1. *Pyramidal tungsten,* or *scheelium.* Colour white. Massive, and sometimes crystallized. The primitive form is a rather acute double four-sided pyramid. Secondary forms are; the primitive figure bevelled on the angles; a very acute double four-sided pyramid; a flat double four-sided pyramid; a square lenticular figure; and a flat double four-sided pyramid. Shining. Fracture uneven. Cleavage ninefold. Translucent. Harder than fluor spar. Brittle. Sp. gr. 6 to 6.1. Its constituents are, oxide of tungsten 65, lime 31, silica 4.—*Scheele;* oxide of tungsten 75.25, lime 18.70, silica 1.56, oxide of iron 1.25, oxide of manganese 0.75.—*Klaproth.* It occurs along with tinstone and wolfram, in Cornwall; in Sweden; Saxony, &c.

2. *Wolfram.*

Prismatic wolfram. Colour black. Massive and crystallized. Primitive form is an oblique four-sided prism of 120°. Secondary forms are; the oblique four-sided prism, bevelled, truncated or acuminated; and a twin crystal. Shining. Fracture uneven. Opaque. Streak dark reddish-brown. Harder than apatite. Brittle. Sp. gr. 7.1 to 7.4. Its constituents are, tungstic acid 67, oxide of manganese 6.25, oxide of iron 18.10, silica 1.5.—*Vauquelin.* It occurs in gneiss in the island of Rona of the Hebrides, and in Cornwall.

XXIII.—Uranium Ores.

1. *Uran ochre.*

a. *Friable.* Colour lemon-yellow. It occurs as a coating on pitch ore. It is composed of dull, weakly cohering particles. It feels meagre.

b. *Indurated.* Colour straw-yellow. Massive and superimposed. Glimmering. Opaque. Soft. Sp. gr. 3.15. The yellow varieties are pure oxide of uranium. The brownish and reddish contain a little iron. It is found in Bohemia and Saxony.

2. *Indivisible uranium,* or *pitch ore.* Colour greenish-black. Massive, reniform and in distinct concretions. Shining. Hardness between apatite and feldspar. Opaque. Brittle. Sp. gr. 6.4 to 6.6. Its constituents are, oxide of uranium 86.5, black oxide of iron 2.5, galena 6.0, silica 5.—*Klaproth.* It occurs in primitive rocks. It is found in Cornwall.

3. *Uranite,* or *uran mica.*

Pyramidal uran mica. Colour grass-green. In flakes and crystallized. Primitive form, a pyramid in which the angles are 95° 13′ and 144° 56′. The secondary forms are, a rectangular four-sided table or short prism, and a four-sided table variously bevelled and truncated. Shining. Cleavage fourfold and rectangular. Transparent and translucent. Scratches gypsum, but not calcareous spar. Streak green. Sectile. Not flexible. Easily frangible. Sp. gr. 3.1 to 3.2. It decrepitates violently before the blow-pipe on charcoal; loses about 33 per cent. by ignition, and acquires a brass-yellow colour. Its constituents are, oxide of uranium, with a trace of oxide of lead 74.4, oxide of copper 8.2, water 15.4.—*Gregor.* It occurs in veins in primitive rocks. It is found in Cornwall and Saxony.

XXIV.—Wodanium Ores.

Woodan pyrites. Colour dark tin-white. In vesicular massive portions. Lustre shining and metallic. Fracture uneven. Opaque. Harder than fluor, but softer than apatite. Brittle. Sp. gr. 5.192. It contains 20 per cent of wodanium, combined with sulphur, arsenic, iron, and nickel. It is said to occur at Topschau in Hungary.

XXV.—Zinc Ores.

1. *Red zinc*, or *red oxide of zinc*. Colour blood-red. Massive, disseminated. On the fresh fracture, shining. Cleavage single. Fracture conchoidal. Translucent on the edges. Easily scratched by the knife. Brittle. Streak brownish-yellow. Sp. gr. 6.22. It is soluble in the mineral acids. Its constituents are, zinc 76, oxygen 16, oxides of manganese and iron 8.—*Bruce*. It has been found in New Jersey, North America.

2. *Zinc blende.*

Dodecahedral zinc blende.

a. Yellow. Wax-yellow, and several other colours, inclining to green. Massive, disseminated, and crystallized in octohedrons, rhomboidal dodecahedrons, and twin crystals. Splendent and adamantine. Cleavage dodecahedral, or sixfold. Translucent. Refracts single. Streak yellowish-gray. Harder than calcareous spar. Brittle. Sp. gr. 4. to 4.2. It becomes phosphorescent by friction. Its constituents are, zinc 64, sulphur 20, iron 5, fluoric acid 4, silica 1, water 6.—*Bergmann*. It occurs in veins, associated with galena. It is found at Clifton mine, near Tyndrum, in Perthshire, also in Flintshire. Fine specimens are found in Bohemia.

b. Brown zinc blende.

§ 1. *Foliated.* Colour reddish-brown. Massive, disseminated, and crystallized, in a rhomboidal dodecahedron, an octohedron, a tetrahedron, and acicular crystals. Lustre between pearly and adamantine. Cleavage sixfold or tessular. Translucent. Streak yellowish-brown. Sp. gr. 4.048. Its constituents are, zinc 58.8, sulphur 23.5, iron 8.4, silica 7.0.—*Dr. Thomson*. It occurs in veins and beds, in primitive and transition rocks. It is found in the Clifton lead mine, near Tyndrum; at Cumberhead in Lanarkshire; at Leadhills; and in all the lead mines in England and Wales.

§ 2. *Fibrous.* Colour dark reddish-brown. Massive, reniform, and in radiated concretions. Glistening, inclining to pearly. Opaque. Its constituents are, zinc 62, iron 3, lead 5, arsenic 1, sulphur 21, alumina 2, water 4. It occurs in Huel-Unity copper mine in Cornwall.

c. Black zinc blende. Colour between grayish and velvet-black. Massive, disseminated, and crystallized in the same figures as brown blende. Shining, adamantine. Opaque. The blood-red variety is translucent on the edges and angles. Streak dark yellowish-brown. Sp. gr. 4.1665. Its constituents are oxide of zinc 53, iron 12, arsenic 5, sulphur 26, water 4. The black blende from Naygag, besides zinc, iron, and manganese, contains a portion of auriferous silver. It occurs in veins in gneiss, in Sweden, Saxony, &c.

Of the Analysis and Reduction of Ores.

By consulting the table of metallic precipitants, and studying the peculiar habitudes of the individual metals and earths, the reader may acquire a knowledge of the methods of separating them from one another, and determining the proportion of each. The limits of the present work permit me to offer merely a short account of the best modes of analyzing a few of the principal ores on the small scale, and of reducing them on the large.

1. Antimony.

1. *Native antimony* was skilfully examined by Klaproth, the father of accurate analysis, as follows: On 100 grains of the pulverized mineral, he poured strong nitric acid, which attacked it with vehemence, converting it into an oxide; which being precipitable by water, he diluted the solution with this liquid, and then filtered. The clear liquid was treated with muriatic acid, which threw down the silver present, in the state of muriate, equivalent to 1 grain of the precious metal. Prussiate of potash then indicated ¼ of a grain of iron. The oxide of antimony was now dissolved in muriatic acid, the solution diluted with water, and a piece of zinc being introduced, precipitated 98 grains of metallic antimony. Hence the 100 grains of native antimony from Andreasberg, consisted of

metallic antimony, -	98
silver, - - - -	1
iron, - - - -	0.25
	99.25

Dr. Thomson has committed a curious mistake in describing this analysis. He says, "When the acid emitted no longer any nitrous gas, the mixture was diluted with water, and thrown upon a filter. *The solution was then treated with nitrate of silver.* The precipitate yielded by reduction, 1 grain of silver."—System, 5th edition, iii. p. 608. How 1 grain of silver was obtained by treating the solution with nitrate of silver, it is not for me to divine.

2. *Fibrous red antimonial ore.* Klaproth digested 100 grains with muriatic acid, mixed with a few drops of nitrous, in a long-necked matrass. There was a gray residuum of 1½ grains of sulphur. "The antimony contained in the solution was precipitated in the state of a white oxide, by diluting it with water, and the small portion of the metal still remaining in that fluid, was afterwards entirely thrown down by means of potash. The oxide thus procured was redissolved in

muriatic acid, the solution diluted with six times its quantity of water, and once more combined with such a proportion of the same solvent, as was necessary in order to redissolve entirely that portion of the oxide which the affused water had precipitated. After the dilute solution had, in this manner, again been rendered clear, its ingredient antimony was reproduced as metallic antimony, by immersing polished iron in the liquor. It weighed, when collected, edulcorated, and dried, 67½ grains."—*Klaproth's Analytical Essays*, vol. ii. p. 143. *English Translation.* From the above result, and Thenard's statement of the constitution of the oxide, Klaproth inferred, that the mineral consisted of,

Metallic antimony,	67.5
Oxygen, -	10.8
Sulphur, -	19.7
	98.0

It is painful to be obliged again to point out a very absurd error in Dr. Thomson's account of this analysis. He says, "The solution was diluted with water. The whole precipitated in the state of a white powder; for potash threw nothing from the liquid." It is hard to say whether the matter or expression be here more remarkable. *Potash did throw something from the liquid;* and must do so, because oxide of antimony is soluble in an excess of muriatic acid; on which fact, indeed, this and the preceding analysis are founded.

3. "Sulphuret of antimony is to be treated with nitro-muriatic acid. The sulphur and the muriate of silver (if any silver be present) will remain. Water precipitates the antimony; sulphuric acid the lead; and ammonia the iron."—*Thomson's System*, 5th edition, iii. 609. This paragraph betrays a strange forgetfulness of the first principles of chemistry; for, in the first place, nitro-muriatic acid will acidify a portion of the sulphur, and therefore the *sulphur will not remain;* in the second place, a portion of oxide of antimony will continue combined with the excess of muriatic acid; and, in the third place, the acidified sulphur will throw down, at first, the lead in the state of insoluble sulphate, along with the muriate of silver.

If the pulverized sulphuret of antimony be acted on by nitric acid, with heat, and water be afterwards added, a precipitate will fall, consisting of oxide of antimony, with sulphur and sulphate of lead. Sulphate of silver being very soluble in dilute nitric acid, will remain in the liquid. Muriate of soda will throw down the silver, without affecting the lead, if the solution be hot and somewhat dilute. The lead, if any remain, may then be precipitated by sulphate of soda in equivalent quantity, or by hydrosulphuret of ammonia; by muriate of barytes, the sulphuric acid resulting from acidification of the sulphur may be ascertained; and by ferroprussiate of potash, the iron. On the first precipitate obtained by affusion of water, if muriatic acid be digested, the oxide of antimony will be taken up, and may be recovered in the metallic state, by immersing a piece of zinc or iron in the muriatic solution. *Lastly*, the sulphur may be separated from the sulphate of lead by ustulation.

Metallic antimony is best obtained from the sulphuret, by igniting it, after careful ustulation, with half its weight of crude tartar. The metal will be found at the bottom of the crucible. Or the ustulated oxide, mixed with oil, fat, and pounded charcoal, is to be ignited till drops of the metal begin to appear; and nitre equal to 1-16th of the weight of the oxide is then to be gradually injected. Or we form the martial regulus of antimony (antimony containing a little iron and sulphur), by adding 16 ounces of the sulphuret to six ounces of iron nails, ignited to whiteness in a crucible. When the whole are in fusion, inject gradually two ounces of pulverized nitre; then cover the crucible, and urge the heat for a little. Seven or eight ounces of the regulus will be found at the bottom. By repeating the fusion, and projection of nitre, two or three times, the regulus may be brought nearer to the state of pure metal.

In what follows, I shall confine myself to the detail of a few ingenious and exact analyses.

2. Bismuth Ores.

The following analysis of a complex metallic mineral by Klaproth is peculiarly instructive.

Examination in the humid way of the bismuthic silver ore from Schaupbach, in the Black Forest, in Suabia.

(*a.*) Upon 300 grains of this ore, he poured three ounces of nitric acid, diluted with one ounce of water. The residuum being acted on with more acid, both solutions were mixed, and evaporated to a small volume; during which process, there separated from the fluid some crystalline grains, consisting of nitrate of lead.

(*b.*) The concentrated solution had a greenish colour. When afterwards diluted with just as much water as was requisite to redissolve that crystalline sediment, it was poured into a large quantity of water. This last immediately acquired a milky appearance, in a high degree, and deposited a white precipitate, which weighed 44½ grains, when collected, lixiviated, and dried in the air, and proved, on further examination, to be oxide of bismuth.

(*c.*) Into the liquor, that had been freed from this oxide, and was entirely clear and colourless, he then dropped muriatic acid as long as it was rendered turbid by it. The precipitate, which now fell, did not appear to be mere muriate of silver; for this reason he digested it for some time with a moderately strong nitric acid. A considerable portion of it was thus redissolved, and left pure horn-silver behind; which, upon careful collection, and desiccation in a brisk heat, weighed 46 grains. Thus, the portion of pure silver is determined at 34½ grains.

(*d.*) The nitric acid that had been affused upon the precipitate obtained by the muriatic (*c*), yielded by dilution with much water, 32 grains more of oxidized bismuth; which, with the preceding 44½ (*b*), gave together 76½ grains. In order to ascertain the proportion of reguline bismuth in this ore, he dissolved 100 grains of bismuth in nitric acid; and after having concentrated the solution by evaporation, he poured it into a large quantity of water. When, of the precipitate thus produced, nothing more would fall down, on adding more water he collected it, on the filter, washed it, and suffered it to dry perfectly in the air. It then weighed 88 grains. To the water which had been separated from it, muriatic acid was added by drops; whereby a new precipitate ensued, weighing 32 grains, after edulcoration and drying.

As, by the result of this comparative experiment, 100 grains of bismuth have, upon the whole, given 123 grains of oxide, it follows that the 76½ grains of oxide (*d*), obtained from 300 grains of this ore, contain 62⅕ grains of metallic bismuth.

(*e*) The remainder of the fluid was further reduced by evaporation; and in this process, muriate of lead separated from it in delicate broad striated crystals. This liquor was then combined with such a quantity of sulphuric acid, as was requisite to redissolve those crystals, and a second time evaporated to a consistence of pap. The precipitate which thence ensued, was sulphate of lead, weighing 19 grains, when duly collected, washed and dried.

(*f.*) What still remained of the solution, after its having been freed from the lead before contained in it, was saturated with caustic ammonia added in excess. In this way, a brown ferruginous precipitate was produced; which was rapidly attracted by the magnet, and weighed 14 grains, when, after previous desiccation, it had been moistened with linseed oil, and well ignited. For these we must reckon 10 grains of metallic iron.

(*g.*) The liquor which had been supersaturated with ammonia, and which, by its blue colour, shewed that it held copper in solution, was saturated to excess with sulphuric acid. On immersing then a piece of polished iron into it, two grains of *copper* were deposited.

(*h.*) The gray residue of the ore, that was left behind by the nitric acid (*a*), weighed 178 grains. But when its sulphureous part had been deflagrated, in a crucible gently heated, it weighed only 140½ grains. This determines the portion of sulphur at 37½ grains.

(*i.*) These 140½ grains were digested with three ounces of muriatic acid, in a heat of ebullition; and the process was repeated once more with 1½ ounce of the same acid. These solutions, by means of evaporation, yielded till the end, muriate of lead in tender spicular, and likewise in broad striated crystals; which, when again dissolved in the requisite quantity of boiling water, then combined with sulphuric acid, and evaporated, yielded 89 grains of sulphate of lead. Thus, the whole quantity of this sulphate, including the 19 grains mentioned at (*e*), amounted to 108 grains; for which, according to comparative experiments, 76 grains of reguline lead must be put in the computation.

(*k.*) That portion of the ore examined, which still remained after all the constituent parts before mentioned had been discovered, consisted merely of the *gray quartzose matrix*; the weight of which, in the ignited state, amounted to 70 grains.

Therefore, these 300 grains of bismuthic silver ore were decomposed into

		Exc. of mat.
Lead, (*i*)	76.00	33.00
Bismuth, (*d*)	62.20	27.00
Silver, (*c*)	34.50	15.00
Iron, (*f*)	10.00	4.30
Copper, (*g*)	2.00	0.90
Sulphur, (*h*)	37.50	16.30
Quartzose matrix, (*k*)	70.00	
	292.20	96.5

3. *Analysis of* CERITE *by Vauquelin*:—

The specimen was of a slight rose colour; and sufficiently hard to scratch glass. Sp. gr. 4.53. Streak grayish. It reddened with calcination, losing 12 per cent.

(*a*) 100 grains of this mineral, in fine powder, were mixed with ten times their weight of nitro-muriatic acid, and subjected to ebullition for an hour; the mixture being diluted with water, and filtered, left on the filter a brown dust, which was dried and fused with caustic potash. The mixture being diluted with water, and then dissolved in muriatic acid, evaporated to dryness, and redissolved in water, left a powder which, when collected on a filter, washed and calcined, weighed 17 parts; it was pure silex, still slightly coloured yellow.

(*b.*) The nitro-muriatic solution being evaporated to dryness, and its residuum redissolved in water, left about one part of silex, coloured by a little oxide of cerium.

(*c.*) The same solution, freed from silex, and united to the washings of the silex, was decomposed by ammonia; the oxide of cerium and the oxide of iron, precipitated by this means, were separated from the liquid by filtration. The oxalic acid added to this liquid, formed a precipitate, which, by calcination, gave two parts of lime.

(*d.*) The metallic oxides united and calcined, weighed 70 parts; they had a beautiful reddish-brown colour. To separate the iron from the cerium, the whole was dissolved in muriatic acid; the solution being concentrated to evaporate the excess of acid, then diluted with water, and decomposed by tartrate of potash, there was formed a very abundant white precipitate, which being washed till it contained no more foreign salts, then dried and calcined, gave 67 parts of oxide of cerium.

(*e.*) The water from the washing of the tartrate of cerium, being united and mixed with hydrosulphuret of potash, gave a precipitate which became black in the air. It was oxide of iron, the weight of which, after calcination, was two parts.

Thus, 100 parts of cerite furnished by this analysis,

Silica, (*a*) (*b*)	17
Lime, (*c*)	2
Oxide of iron, (*d*)	2
Oxide of cerium, (*e*)	67
Water and carbonic acid, by estimate,	12
	100

4. Copper Ores. Analysis of Siberian malachite, by Klaproth:—

(*a.*) 100 grains of malachite reduced to powder by trituration, were dissolved in nitric acid; which was effected without leaving any residue. The solution had a bright blue colour; and was saturated to excess with ammonia; but the precipitate produced was entirely and without tardiness redissolved by the excess of the alkali. This shewed that the malachite here examined was perfectly free from iron, and similar admixtures.

(*b*) He combined 100 grains of triturated malachite, with a sufficient quantity of sulphuric acid, previously diluted with five parts of water, and accurately weighed together with the vessel. After the malachite had been wholly dissolved, which was effected gradually, and with a moderately strong effervescence, the loss of weight occasioned by the carbonic acid gas, that was extricated, was found to consist of 18 gr.

(*c.*) 100 grains of the same powdered malachite, were ignited at a moderate heat in a covered crucible. The black residue had lost 29½ grains in weight. If from these be subtracted 18 grains for the carbonic acid, the remaining 11½ grains of loss will consist of water.

(*d.*) And lastly, 100 grains, which had been dissolved in dilute sulphuric acid, and precipitated by zinc, yielded 58 grains of pure copper.

In consequence of these experiments, the Siberian malachite consists of

Copper,	58
Carbonic acid,	18
Oxygen,	12.5
Water,	11.5
	100.0

5. Gold Ores. A very instructive analysis of the Transylvanian auriferous lamellar ore, from Naygag, by Klaproth:—

(*a.*) 1000 grains, freed in the best possible manner from the stony matrix, were triturated, and digested at a moderate heat, first with ten ounces of muriatic acid, to which nitric acid was gradually added. A violent action then took place, and the black colour of the powdered ore rapidly disappeared. While the fluid was yet hot, it was poured upon a filter, and the residue was once more digested with five ounces of muriatic acid, and the whole filtered. In a short time acicular crystals were deposited in the solution, which was yellow, and likewise on the filtering paper. These crystals were covered with boiling hot water, till they were all dissolved; after which only the quartzose portion of the matrix and some sulphur remained.

(*b.*) The sulphurous ingredient in the ore, had united into a coherent mass, and could therefore be easily removed from the earthy residue. Its weight was 17½ grains. Burned on a moderately heated calcining test, it left 3½ grains of blackish residuum, which was dissolved in muriatic acid and added to the foregoing solution. Hence the quantity of sulphur was 14 grains.

(*c.*) That portion of the matrix which consisted of white grains of quartz, weighed in the dry state 440½ grains. This being mixed with four times its quantity of carbonate of potash, was melted to vitrifaction. On breaking the crucible, a few globules of silver were found dispersed; which, however, could not be well collected. But from another experiment, to be mentioned in the sequel, it resulted, that this *silver* may be estimated at 2½ grains. Whence, since in the present case, it was in the state of muriate, 3½ grains are to be subtracted, so that of the above stated weight 437 grains remain.

(*d.*) The solution (*a*), from which, on addition of the edulcorating water, a white telluric oxide fell down in a great quantity, was concentrated by evaporation; during which process that precipitate again entirely dissolved. On the other hand, numerous crystals of muriate of lead were deposited from the liquor, even while warm; which being taken out, the evaporation was carried on as long as any more of them appeared. These crystals, when collected, were carefully rinsed by dropping upon them muriatic acid, and highly dried. They weighed 330 grains, equivalent to 248 grains of lead in the metallic state.

(*e.*) After the concentrated solution had been thus freed from lead, he diluted it a little with water, and added a large quantity of spirit of wine, as long as any white precipitate fell. The mixture having stood for a while in a gentle warmth, that precipitate was collected on the filter, edulcorated with ardent spirit, redissolved in muriatic acid, and precipitated again in the state of a pure telluric oxide, by means of caustic soda, and by strictly watching the precise point of saturation. This oxide, washed and dried, gave in the balance 178 grains, which correspond to 148 grains of reguline tellurium.

(*f.*) For the purpose of ascertaining the proportion of gold, he now reduced the fluid, from which the tellurium had been separated, by distilling off the spirit of wine in a retort; diluted again the concentrated solution with water; and lastly, dropped into it a nitric solution of mercury, prepared without the assistance of heat; adding this nitrate, until no brown precipitate any longer appeared, and till the white precipitate which succeeded the brown, no more changed its own colour. After this the mixture was placed in a warm temperature, where the white precipitate, which was owing to the nitrated mercury added in excess, again gradually disappeared. The brown precipitate, which fell to the bottom as a heavy powder, was the gold sought for. When collected and fused with nitrate of potash, it gave a bead of pure gold, weighing 41½ grains.

(*g.*) The liquor was now saturated with carbonate of soda, in a boiling heat. A copious bluish-gray precipitate ensued, which turned black-brown by ignition. Digested with muriatic acid, it dissolved again clearly, and gave out oxygenated muriatic acid gas. By combining this solution with liquid carbonate of ammonia to a considerable degree of supersaturation, a grayish-white precipitate was produced; which, collected, washed, and dried, weighed 92 grains, and proved to be a somewhat iron shot, carbonated oxide of manganese.

(*h.*) The ammoniacal lixivium (*g*) appeared of a blue colour. After being supersaturated with sulphuric acid, by which it was again rendered colourless, a small plate of polished iron was introduced, and the vessel put in a warm place. The iron became gradually coated with copper, the weight of which after drying was six grains.

Therefore the 1000 grains were decomposed into

		Exclusive of the matrix of quartz and mangnesian ore,
Lead, (*d*)	248.0	54.0
Tellurium, (*e*)	148.0	32.2
Gold, (*f*)	41.5	9.0
Silver, (*c*)	2.5	0.5
Copper (*h*)	6.0	1.3
Sulphur, (*b*)	14.0	3.0
Oxide of manganese, (*g*)	92.0	——
Quartz, (*c*)	437.0	100.0
	989.0	
Loss,	11.0	
	1000.0	

6. **Iron Ores** are usually analyzed by fusion. On this subject, there is a valuable essay by Mr. Mushet, in the 4th volume of the Phil. Magazine. In the hematites iron ore, for 1 pound avoirdupois, he commonly added 6 ounces dried chalk, and ¾ of an ounce of charcoal; and for the splinty blue ore also a similar mixture. From both of these mixtures, he obtained the richest sort of crude iron. The kidney ore will admit of a diminution of chalk, and a small addition of glass. One pound avoirdupois of this variety will be accurately assayed by the addition of 5 ounces chalk, 1 ounce glass, and ¾ of an ounce of charcoal. The same proportion of mixtures will also accurately reduce the small pieces of this ore, commonly of a soft greasy consistence, mixed with small fragments of the hematites and the kidney, and will give out the iron which they contain, supercarburetted. A mixture of this soft ore, with kidney, is preferred to the richer variety, at the iron manufactories. The Lancashire ore consists chiefly of this compound, and the poorer in iron has always a decided preference given it, at the blast-furnace. The Elba ore may be reduced into smooth carburetted iron, by exposing to a melting heat 2 ounces of it mixed with 2 ounces of chalk, 1½ ounce bottle-glass, and ¼ ounce of charcoal. To the Islay iron ore, and the Norwegian, Danish, and Swedish, Mr. Mushet adds, for every pound, 7 ounces of dried chalk, 3 of bottle-glass, and 1 of charcoal. By carburetted iron is meant cast-iron.

I shall now give an outline of Mr. Hatchett's much admired analysis of the magnetical pyrites.

(*a.*) 100 grains reduced to a fine powder, were digested with two ounces of muriatic acid, in a glass matrass placed in a sand-bath. A strong effervescence ensued, occasioned by the production of sulphuretted hydrogen gas; and a pale yellowish-green solution was formed. The residuum was then again digested with two parts of muriatic acid, mixed with one of nitric acid; and a quantity of pure sulphur was obtained, which, being dried, weighed 14 grains.

(*b.*) The acid in which the residuum had been digested, was added to the first muriatic solution; some nitric acid was also poured in to promote the oxidizement of the iron, and thereby to facilitate the precipitation of it by ammonia, which was added after the liquor had been boiled for a considerable time. The precipitate thus obtained was boiled with lixivium of potash; it was then edulcorated, dried, made red-hot with wax in a covered porcelain crucible, and completely taken up by a magnet, and being weighed, amounted to 80 grains.

(*c.*) The lixivium of potash was examined by muriate of ammonia, but no alumina was obtained.

(*d.*) To the filtered liquor, from which the iron had been precipitated by ammonia, muriate of barytes was added, until it ceased to produce any precipitate; this was then digested with some very dilute muriatic acid; was collected, washed, and after exposure to a low red heat, for a few minutes in a crucible of platinum. weighed 155 grains. If therefore the quantity of sulphur converted into sulphuric acid by the preceding operations, and precipitated by barytes, be calculated according to the experiments of M. Chenevix, then, 155 grains of sulphate of barytes. will denote nearly 22.5 of sulphur, (21. Dr. Wollaston's scale); so that with the addition of the 14 grains previously obtained in substance, the total quantity will amount to 36.5, (35).

(*e*.) Moreover, from what has been stated, it appears, that the iron which was obtained in the form of black oxide, weighed 80 grains; and by adding these 80 grains to the 36.5 of sulphur, an increase of weight is found = 16.5. This was evidently owing to the oxidizement of the iron, which in the magnetical pyrites, exists quite or very nearly in the metallic state; but by the operations of the analysis, has received this addition. The real quantity of iron must on this account be estimated at 63.5. 100 grains therefore, of the magnetical pyrites yielded,

Sulphur,	(*a*) 14.0 (14) (*d*) 22.5 (21)	36.5	(35)
Iron,	(*e*)	= 63.5	(62.22)
		100.0	97.22

This analysis was repeated in a similar manner, excepting that the whole was digested in nitric acid, until the sulphur was entirely converted into sulphuric acid. To the liquor which remained after the separation of the iron by ammonia, muriate of barytes was added, as before, and formed a precipitate which weighed 245 grains. Now these, by Dr. Wollaston's scale, are equivalent to nearly 33.5 of sulphur. Hence it would appear, that a little sulphur is dissipated, in the form of sulphurous acid, by this mode of operation.

The theoretical equivalent proportions of magnetic pyrites are,

Sulphur,	36.363	2.00
Iron,	63.636	3.50

We thus see, that Mr. Hatchett's final statement is almost exact, in consequence of M. Chenevix's erroneous estimate of the composition of sulphuric acid and sulphate of barytes, making a compensation for the experimental deviation, or loss; amounting on the iron to 1.416, and on the sulphur to 1.363, in the 100 parts.

Analysis of arseniate of iron, by M. Chenevix :—

100 grains boiled with potash left 58.5. The liquor treated by nitrate of lead, gave of arseniate of lead, a quantity which he estimated as equivalent to 31 of arsenic acid. The 58.5 left 4, which muriatic acid could not dissolve, and which were silica. Ammonia dissolved 9, and there remained 45.5 of oxide of iron. This analysis presents the following results:

Arsenic acid, -	31.00
Oxide of iron, -	45.50
Oxide of copper, -	9.00
Silica, - -	4.00
Water, by inference,	10.50
	100.00

7. **Lead Ore.** Analysis of yellow lead ore from Wanlockhead, by Klaproth :—

(*a*.) Upon 100 grains of this ore finely levigated, dilute nitric acid was poured and heated. They dissolved, and only a few inconsiderable flocks escaped the action of the solvent. The filtered colourless solution, when treated with nitrate of silver, gave 10½ muriate of silver, which indicates, says Klaproth, 1.62 grains dry muriatic acid.

(*b*.) Sulphuric acid was then presented to the solution. It precipitated the lead contained in that fluid in the state of sulphate; which having suffered a red heat, weighed 108⅛ grains; for which 80 grains of oxide of lead must be allowed.

(*c*.) The excess of sulphuric acid being separated by means of nitrtae of barytes, ammonia was added to the saturation of the nitric acid, and the phosphoric acid was then thrown down with acetate of lead. From 80 grains of phosphate of lead thus obtained, he inferred 18 grains of phosphoric acid to have existed in the ore.

The residuary part of the fluid contained nothing more of the constituent parts of the mineral, excepting a slight trace of iron. Consequently 100 gr. were resolved into—

Oxide of lead,	80.
Phosphoric acid,	18.
Muriatic acid,	1.62
	99.62

8. Analysis of **Gray Silver Ore**, by Klaproth :—

(*a*.) 300 grains of the fragments selected from the pounded ore, though not perfectly separable from the quartzose gangue, with which they were firmly concreted, were levigated to a subtle powder, and digested with four times their weight of nitric acid. The digestion was renewed with the residuum, in an equal quantity of the same acid; and the portion which still remained undissolved then assumed a grayish-yellow colour, and weighed 188 grains.

(*b*.) By the addition of muriate of soda to the bright green nitric solution, its silver was thrown down; and this precipitate collected and reduced by means of soda, yielded 31½ grains of metallic silver.

(*c*.) The silver being thus separated, he tried the solution for lead; but neither the neutral sulphates, nor free sulphuric acid, could discover the least sign of it.

(*d*.) After this he added caustic volatile alkali, so as to supersaturate the acid; upon which a reddish-brown precipitate, of a loose cohesion, appeared, that by ignition became of a black-brown, and weighed 9¼ grains. It dissolved in nitric acid, leaving behind it half a grain of siliceous earth. Prussiate of potash produced from the filtered solution a deep blue precipitate of iron; and after this was separated, 1½ grains of alumina were obtained from it by means of soda. Therefore subtracting the siliceous and argillaceous earths, the portion of iron attractible by the magnet amounted to 7¼ grains.

(*e.*) To the solution, which had been before supersaturated with pure ammonia, and exhibited a sapphire-blue colour, sulphuric acid was now added to excess. A polished piece of iron was then immersed into the fluid, from which it precipitated 69 grains of copper.

(*f.*) The above grayish-yellow residuum (*a*) was now to be examined. It was digested with six times its quantity of muriatic acid, in a heat of ebullition. When filtered, the residue which was left on the paper, being first washed with muriatic acid, then with a little alcohol, and lastly dried, was found to weigh 105½ grains.

(*g.*) From the solution which was obtained by the last process, and was of a straw-yellow, the greater part of the fluid was drawn off by a gentle distillation in a retort. The remaining concentrated solution then deposited some crystalline grains, which were carefully collected, and proved upon inquiry to be muriate of silver, weighing ¼ of a grain. A large quantity of water being next poured into the solution, a copious precipitate subsided, weighing after desiccation 97¼ grains. It proved by every test to be oxide of antimony, for which, as was found by comparative experiments, 75 grains of reguline antimony must be allowed.

(*h.*) The residue obtained (*f*) weighing 105½ grains, which comprised the sulphureous part of the ore, was exposed to a low heat, by which treatment the sulphur was consumed, and 80¼ grains of silica remained. Hence the quantity of the sulphur was equal to 25¼ grains.

(*i.*) The siliceous earth was next fused with four times its weight of black flux. The melted mass entirely dissolved in twice its weight of water into liquor of flints; some minute particles of silver, weighing three-fourths of a grain, excepted. According to this, the proportion of silica amounted to 79½ grains.

The whole constituents therefore are,—

				Ore, exclusive of silica, in 100.
Silver,	(*b*)	31.5	32.50	14.77
	(*g*)	0.25		
	(*i*)	0.75		
Copper,	(*e*)		69.00	31.36
Antimony,	(*g*)		75.00	34.09
Iron,	(*d*)		7.25	3.30
Sulphur,	(*h*)		25.25	11.50
Alumina,	(*d*)		1.50	0.30
				———
Silica,	(*d*) and (*i*)		80.00	95.32

9. Analysis of TIN ORES by Klaproth :—

1. Tinstone.

(*a.*) 100 grains of tinstone from Alternon, in Cornwall, previously ground to a subtle powder, were mixed in a silver vessel, with a lixivium containing 600 grains of caustic potash. This mixture was evaporated to dryness in a sand heat, and then moderately ignited for half an hour. When the gray-white mass, thus obtained, had been softened while yet warm with boiling water, it left on the filter 11 grains of an undissolved residue.

(*b.*) These 11 grains, again ignited with 6 times their weight of caustic potash, and dissolved in boiling water, left now only 1¼ grains of a fine yellowish-gray powder behind.

(*c.*) The alkaline solution, (*a* and *b*), which was in some degree colourless, was saturated with muriatic acid. A brilliant white tender oxide of tin was thrown down giving to the mixture a milky appearance, This precipitate, redissolved by an additional quantity of muriatic acid, was precipitated afresh by means of carbonate of soda. When lixiviated and dried in a gentle heat, it acquired the form of bright yellowish transparent lumps, having in their fracture a vitreous lustre.

(*d.*) This precipitate being finely powdered, soon dissolved entirely in muriatic acid, assisted by a gentle heat. Into the colourless solution, previously diluted with from 2 to 3 parts of water, he put a stick of zinc; and the oxide of tin, thus reduced, gathered around it, in delicate dendritic laminæ, of a metallic lustre. These, when collected, washed, dried, and fused under a cover of tallow, in a capsule placed upon charcoal, yielded a button of pure metallic tin, weighing 77 grains.

(*e.*) The above mentioned residue of 1¼ grains, left by the treatment with caustic potash (*b*), afforded with muriatic acid a yellowish solution; from which, by means of a little piece of zinc introduced into it, ½ grain of tin was still deposited. Ferroprussiate of potash, added to the remainder of the solution, produced a small portion of a light blue precipitate; of which, after deducting the oxide of tin, now combined with it, hardly ¼ of a grain remained, to be put to the account of the iron, contained in the tinstone, here examined.

In these experiments, (excepting only a slight indication of silex, amounting to about ¼ of a grain), no trace appeared, either of tungstic oxide, which some mineralogists have supposed to be one of the constituent parts of tinstone, nor of any other fixed substance. Therefore what is deficient in the sum, to make up the original weight of the mineral analyzed, must be ascribed to the loss of oxygen; and thus the constituent parts of pure tinstone from Alternon, are to each other in the following proportion :

Tin,	77.50
Iron,	0.25
Silica,	0.75
Oxygen,	21.50
	100.00

2. Tin pyrites, from Wheal-Rock, St. Agnes in Cornwall.

(*a*.) 120 grains of finely triturated tin pyrites were treated with an aqua regia, composed of 1 ounce muriatic acid, and ½ ounce of nitric acid. Within 24 hours, the greatest part of the metallic portion was dissolved in it, without application of heat; while the sulphur rose up and floated on the surface of the menstruum. After the mixture had been digested upon it for some time in a low sand heat, it was diluted with water, and thrown on a filter. It left 43 grains of sulphur on the paper, still, however, mixed with metallic particles. When the sulphur had been gently burnt off on a test, there still remained 13 grains; of which 8 were dissolved by nitro-muriatic acid. The remaining part was then ignited with a little wax; upon which the magnet attracted 1 grain of it. What remained was part of the siliceous matrix, and weighed 3 grains.

(*b*). The solution of the metallic portion (*a*) was combined with carbonate of potash; and the dirty-green precipitate, thus obtained, was redissolved in muriatic acid, diluted with 3 parts of water. Into this fluid, a cylinder of pure metallic tin, weighing 217 grains, was immersed. The result was, that the portion of copper contained in the solution, deposited itself on the cylinder of tin; at the same time that the fluid began to lose its green colour, from the bottom upwards, until after the complete precipitation of the copper in the reguline state, it became quite colourless.

(*c*.) The copper thus obtained weighed 44 grains. By brisk digestion in nitric acid, it dissolved, forming a blue tincture, and left 1 grain of tin behind, in the character of a white oxide. Thus the portion of pure copper consisted of 43 grains.

(*d*.) The cylinder of tin employed to precipitate the copper, now weighed 128 grains; so that 89 grains of it had entered into the muriatic solution. From this, by means of a cylinder of zinc, he reproduced the whole of the dissolved tin, which was loosely deposited upon the zinc, in a tender dendritical form. When the tin was all precipitated, he collected and lixiviated carefully, and suffered it to dry. It weighed 130 grains. By mixing it with tallow, he melted it into grains, under a cover of charcoal dust, in a small crucible; and separated the powder of the coal by elutriation. Among the washed grains of tin, some black particles of iron were observed, which were attractible by the magnet, and weighed 1 grain. Deducting this, there remain 129 grains for the weight of the tin. By substracting again from these last those 89 grains, which proceeded from the cylinder of tin employed for the precipitation of the copper (*b*), there remained 40 grains, for the portion of tin contained in the tin pyrites examined. Hence, including the 1 grain of tin, which had been separated from the solution of the copper (*c*), the portion of pure tin contained in this ore amounted to 41 grains. The following is a view of the results:—

	In 120 gr.	In 100.
Sulphur	30	25
Tin,	41	34
Copper,	43	36
Iron,	2	2
Gangue,	3	—
	——	97
	119	

The darker varieties are considerably poorer in tin. The reduction of the ores of tin is effected, by roasting the ore after it has been pulverized in stamping mills, and then exposing it to heat, in a reverberatory or blast furnace, along with Welch small coal or culm. If much copper be present, it is afterwards fused at a very gentle heat, and what flows off is pretty pure tin.

Zinc is reduced by distillation of its ore (previously roasted) in a retort, along with charcoal.*

A sulphuret of zinc was lately met with in one of the Gwennap mines, incrusting a spongy pyrites intermixed with quartz, and, so like wood-tin, as to be supposed a variety of it by the miners. According to Dr. Kidd, it consists of 66 oxide of zinc, 33 sulphur, and a very minute portion of iron. The pyrites contains cobalt.

In the dry way, zinc is reduced by distilling its ore after torrefaction, with a mixture of its own weight of charcoal, in an earthen retort well luted, and a strong heat: but by this method scarce half the zinc it contains is obtained.

The first dressing of calamine for the large works of zinc, consists in picking out all the pieces of lead ore, lime, and ironstone, cauk, and other heterogeneous substances, which are found mixed with it in the mine: it is then roasted in proper furnaces, where it loses about a third or fourth part of its weight. It is picked out again very carefully, as the heterogeneous particles have become more discernible by the action of the fire; it is then ground to a fine powder, and washed in a gentle rill of water, which carries off the earthy mixtures of extraneous matters; so that, by these processes, a ton of the crude calamine of Derbyshire is reduced to 12 cwt. only.

Bergmann affirms, that a certain Englishman, whose name he does not mention, made, several years ago, a voyage to China, for the purpose of learning the art of smelting zinc, or tutenague; and that he became instructed in the secret, and returned safely home.

It is not improbable, but that a fact of this kind may have served to establish the manufactory of zinc in England about the year 1743, when Mr. Champion obtained a patent for the making of it, and built the first work of the kind near Bristol. It consists, as Watson relates, of a circular kind of oven, like a glass-house furnace, in which were placed six pots, of about four feet each in height, much resembling large oil jars in shape; into the bottom of each pot is inserted an iron tube, which passes through the floor of the furnace, into a vessel of water. A mixture of the prepared ore is made with charcoal, and the pots are filled with it to the mouth, which are then close stopped with strong covers, and luted with clay. The fire being properly applied, the metallic vapour of the calamine issues, downwards, or *per descensum*, through the iron tubes, there being no other place through which it can escape; and the air being excluded, it does not take fire, but is condensed in the water into granulated particles; which, being remelted, are cast into ingots, and sent to Birmingham under the name of zinc, or spelter; although by this last name of spelter, only a granulated kind of soft brass is understood among the braziers, and others who work in London, used to solder pieces of brass together.

***Orichalcum.** The brass of the ancients; their æs was a species of bronze.*

Orpiment.** Sulphuret of arsenic. See **Ores of Arsenic.

***Orthite.** A mineral so named because it always occurs in straight layers, generally in feldspar. It resembles gadolinite, and consists of, peroxide of cerium 19.5, protoxide of iron 12.44, protoxide of manganese 3.44, yttria 3.44, silica 32.0, alumina 14.8, lime 7.84, water 5.36,—*Berzelius*. It is found in the mine of Finbo, in the vicinity of Fahlum in Sweden. The mine is situated in a vein of granite which traverses gneiss.*

* **Osmazome.** If cold water which has been digested, for a few hours, on slices of raw muscular fibre, with occasional pressure, be evaporated, filtered, and then treated with pure alcohol, a peculiar animal principle will be dissolved, to the exclusion of the salts. By dissipating the alcohol with a gentle heat, the osmazome is obtained. It has a brownish-yellow colour, and the taste and smell of soup. Its aqueous solution affords precipitates with infusion of nut-galls, nitrate of mercury, and nitrate and acetate of lead.*

Osmium. A new metal lately discovered by Mr. Tennant among platina, and thus called by him from the pungent and peculiar smell of its oxide. For the mode in which he extracted it, see **Iridium.**

Its oxide may likewise be obtained in small quantity by distilling with nitre the black powder left after dissolving platina; when at a low red heat an apparently oily fluid sublimes into the neck of the retort, which on cooling concretes into a solid, colourless, semi-transparent mass. This being dissolved in water, forms a concentrated solution of oxide of osmium. This solution gives a dark stain to the skin, that cannot be effaced. Infusion of galls presently produces a purple colour in it, which soon after becomes of a deep vivid blue. This is the best test of the oxide. With pure ammonia it becomes yellow, and slightly so with carbonate of soda. With lime it forms a bright yellow solution; but it is not affected either by chalk or by pure magnesia. The solution with lime gives a deep red precipitate with galls, which is turned blue by acids. It produces no effect on solution of gold or platina; but precipitates lead of a yellowish-brown, mercury of a white, and muriate of tin of a brown colour.

Oxide of osmium becomes of a dark colour with alcohol, and after some time separates in the form of black films, leaving the alcohol without colour. The same effect is produced by ether, and much more quickly.

It parts with its oxygen to all the metals except gold and platina. Silver kept in a solution of it some time, acquires a black colour, but does not deprive it entirely of smell. Copper, tin, zinc, and phosphorus quickly produce a black or gray powder, and deprive the solution of smell, and of the property of turning galls blue. This black powder, which consists of the metallic osmium, and the oxide of the metal employed to precipitate it, may be dissolved in nitro-muriatic acid, and then becomes blue with infusion of galls.

If the pure oxide dissolved in water be shaken with mercury, it soon loses its smell, and the metal forms a perfect amalgam. By squeezing the superfluous mercury through leather, and distilling off the rest, a dark gray or blue powder is left, which is the osmium.

Exposed to a strong heat in a cavity in a piece of charcoal, it does not melt; nor is it volatile, if oxidation be carefully prevented. With copper and with gold it forms malleable alloys, which are easily dissolved in nitro-muriatic acid, and afford by distillation the oxide of osmium. The pure metal, previously heated, did not appear to be acted upon by acids. Heated in a silver cup with caustic alkali, it combined with it, and gave a yellow solution, similar to that from which it was procured. From this solution acids separate the oxide of osmium. *Phil. Trans.*

* **Ossifications.** The deposition of calcareous phosphate or carbonate on the soft solids of animal bodies; as in the pineal gland, lungs, liver, &c.* See **Pulm. Concretions.**

* **Oxalates.** Compounds of the salifiable bases with oxalic acid. See **Acid (Oxalic),** and the bases.*

* **Oxalic Acid.** This acid is described

under Acid (Oxalic). It is found in the state of oxalate of lime in the roots of the following plants:—Alkana, apium, bistorta, carlina acaulis, curcuma, dictamnus albus, fœniculum, gentiana rubra, vincetoxicum, lapathum, liquiritia, mandragora, ononis, iris florentina, iris nostras, rheum, saponaria, scilla, sigillum salomonis, tormentilla, valeriana, zedoaria, zingiber. And in the following barks:—berberis, cassia fistularis, canella alba, cinamomum, cascarilla, cassia caryophyllata, china, culilavan, frangula, fraxinus, quassia, quercus, simaruba, lignum sanctum, ulmus. In the state of binoxalate of potash, it exists in the leaves of the oxalis acetosella, oxalis corniculata, different species of rumex, and geranium acidum.

The juice of the cicer parietinum is said to be pure oxalic acid.*

Oxidation. The process of converting metals, or other substances, into oxides, by combining with them a certain portion of oxygen. It differs from *acidification* in the addition of oxygen not being sufficient to form an acid with the substance oxided.

Oxides. Substances combined with oxygen, without being in the state of an acid.

Oxygen Gas. This gas was obtained by Dr. Priestley in 1774, from red oxide of mercury exposed to a burning lens, who observed its distinguishing properties of rendering combustion more vivid and eminently supporting life. Scheele obtained it in different modes in 1775; and in the same year Lavoisier, who had begun, as he says, to suspect the absorption of atmospheric air, or of a portion of it, in the calcination of metals, expelled it from the red oxide of mercury heated in a retort.

Oxygen gas forms about a fifth of our atmosphere, and its base is very abundant in nature. Water contains 88.88 *per cent* of it; and it exists in most vegetable and animal products, acids, salts, and oxides.

This gas may be obtained from nitrate of potash, exposed to a red heat in a coated glass or earthen retort, or in a gun-barrel; from a pound of which about 1200 cubic inches may be obtained; but this is liable, particularly toward the end of the process, to a mixture of nitrogen. It may be expelled, as already observed, from the red oxide of mercury, or that of lead; and still better from the black oxide of manganese, heated red-hot in a gun-barrel, or exposed to a gentler heat in a retort with half its weight, or somewhat more, of strong sulphuric acid. To obtain it of the greatest purity, however, the chlorate of potash is preferable to any other substance, rejecting the portions that first come over as being debased with the atmospheric air in the retort. Growing vegetables, exposed to the solar light, give out oxygen gas; so do leaves laid on water in similar situations, the green matter that forms in water, and some other substances.

Oxygen gas has neither smell nor taste. Its sp. gr. is 1.1111; 100 cubic inches weigh 33.88 gr. It is a little heavier than atmospheric air. Under great pressure water may be made to take up about half its bulk. It is essential to the support of life: an animal will live in it a considerable time longer than in atmospheric air; but its respiration becomes hurried and laborious before the whole is consumed, and it dies, though a fresh animal of the same kind can still sustain life for a certain time in the residuary air.

Combustion is powerfully supported by oxygen gas. Any inflammable substance, previously kindled, and introduced into it, burns rapidly and vividly. If an iron or copper wire be introduced into a bottle of oxygen gas, with a bit of lighted touchwood or charcoal at the end, it will burn with a bright light, and throw out a number of sparks. The bottom of the bottle should be covered with sand, that these sparks may not crack it. If the wire coiled up in a spiral like a corkscrew, as it usually is in this experiment, be moved with a jerk the instant a melted globule is about to fall, so as to throw it against the side of the glass, it will melt its way through in an instant, or, if the jerk be less violent, lodge itself in the substance of the glass. If it be performed in a bell glass, set in a plate filled with water, the globules will frequently fuse the vitreous glazing of the plate, and unite with it so as not to be separable without detaching the glaze, though it has passed through perhaps two inches of water.

Oxygenation. This word is often used instead of oxidation, and frequently confounded with it; but it differs in being of more general import, as every union with oxygen, whatever the product may be, is an oxygenation: but oxidation takes place only when an oxide is formed.

Oxymel. A compound of honey and vinegar.

* Oxymuriatic Acid. Chlorine.*

* Oxyprussic Acid. See Acid (Chloroprussic).*

P

* PAINTS. In the Philosophical Transactions for 1815. Sir H. Davy has communicated the results of some interesting researches, which he had made at Rome, on the colours used by the ancient artists.

He found the reds to be minium, ochre, and cinnabar.

The yellows were ochre, orpiment, and massicot.

The blues were formed from carbonate of copper, or cobalt, vitrified with glass.

The purples were made of shell-fish, and probably also from madder and cochineal lakes.

The blacks and browns were lamp-black, ivory-black, and ores of iron and manganese.

The whites were chalk, white clay, and ceruse.

The Egyptian azure, the excellence of which is proved by its duration for seventeen hundred years, may be easily and cheaply made. Sir H. Davy found, that 15 parts by weight of carbonate of soda, 20 of powdered opaque flints, and 3 of copper filings, strongly heated together for two hours, gave a substance of exactly the same tint, and of nearly the same degree of fusibility, and which when powdered, produced a fine deep sky-blue.

He conceives, that next to coloured frits, the most permanent pigments are those furnished by the peroxides, or persalts, such as ochres, carbonates of copper, patent yellow (submuriate of lead), chromate of lead, arsenite of copper, insoluble chloride of copper, and sulphate of barytes.

M. Merimé has inserted a note very interesting to painters in the *Annales de Chimie et Phys.* for June 1820. When carbonate of lead is exposed for some time to vapours of sulphuretted hydrogen, it becomes black, being converted into a sulphuret. This white pigment, employed with oil, and covered with a varnish, which screens it from the air, may be preserved for many hundred years, as the paintings of the 15th century prove. But when the varnish is abraded or decays, the whites of ceruse are apt to contract black specks and spots, which ruin fine paintings. Miniatures in water colours are frequently injured in this way. M. Thenard was requested to occupy himself with the means of removing these stains, without injuring the rest of the picture. After some trials, which proved that the reagents which would operate on sulphuret of lead, would equally attack the texture of the paper, as well as other colours, he recollected, that among the numerous phenomena which his discovery of oxygenated water had presented to him, he observed the property it possessed, of converting instantly the black sulphuret of lead into the white sulphate of the same metal. He gave a portion of water, containing about five or six times its volume of oxygen, to an artist who had a fine picture of Raphael spotted black. On applying a few touches of his pencil, he perceived the stains vanish as if by enchantment, without affecting the other colours in the slightest degree.*

PALLADIUM. This is a new metal, first found by Dr. Wollaston associated with platina, among the grains of which he supposes its ore to exist, or an alloy of it with iridium and osmium, scarcely distinguishable from the crude platina, though it is harder and heavier.

If crude platina be dissolved in nitro-muriatic acid, and precipitated with a solution of muriate of ammonia in hot water; the precipitate washed, and the water added to the remaining solution, and a piece of clean zinc be immersed in this liquid, till no farther action on it takes place; the precipitate now thrown down will be a black powder, commonly consisting of platina, palladium, iridium, rhodium, copper, and lead. The lead and copper may be separated by dilute nitric acid. The remainder being then digested in nitro-muriatic acid, and common salt, about half the weight of the precipitate, added on the solution, on evaporating this to dryness by a gentle heat, the result will be triple salts of muriate of soda with platina, palladium, and rhodium. Alcohol will dissolve the first and second of these; and the small portion of platina may be precipitated by sal ammoniac. The solution being diluted, and prussiate of potash added, a precipitate will be thrown down, at first of a deep orange, and afterward changing green. This being dried, and heated with a little sulphur before the blow-pipe, fuses into a globule, from which the sulphur may be expelled by exposing it to the extremity of the flame, and the palladium will remain spongy and malleable.

It may likewise be obtained by dissolving an ounce of nitrate of potash in five of muriatic acid, and in this mixture digesting the compound precipitate mentioned above. Or more simply by adding to a solution of crude platina, a solution of prussiate of mercury, on which a flocculent precipitate will gradually be formed, of a yellowish-white colour. This is prussiate of palladium, from which the acid may be expelled by heat.

Palladium is of a grayish-white colour, scarcely distinguishable from platina, and takes a good polish. It is ductile and very malleable; and being reduced into thin slips is flexible, but not very elastic. Its fracture is fibrous, and in diverging striæ, showing a kind of crystalline arrangement. In hardness it is superior to wrought iron. Its sp. grav. is from 10.9 to 11.8. It is a less perfect conductor of caloric than most metals, and less expansible, though in this it exceeds platina. On exposure to a strong heat its surface tarnishes a little, and becomes blue; but an increased heat brightens it again. It is reducible *per se.* Its fusion requires a much higher heat than that of gold; but if touched while hot with a small bit of sulphur, it runs like zinc. The sulphuret is whiter than the metal itself, and extremely brittle.

Nitric acid soon acquires a fine red colour from palladium, but the quantity it dissolves is small. Nitrous acid acts on it more quickly and powerfully. Sulphuric acid, by boiling, acquires a similar colour, dissolving a small portion. Muriatic acid acts much in the same manner. Nitro-muriatic acid dissolves it rapidly, and assumes a deep red.

Alkalis and earths throw down a precipitate from its solutions generally of a fine orange colour; but it is partly redissolved in an excess of alkali. Some of the neutral salts, particularly those of potash, form with it triple compounds, much more soluble in water than those of platina, but insoluble in alcohol.

Alkalis act on palladium even in the metallic state; the contact of air, however, promotes their action.

A neutralized solution of palladium is precipitated of a dark orange or brown by recent muriate of tin; but if it be in such proportions as to remain transparent, it is changed to a beautiful emerald-green. Green sulphate of iron precipitates the palladium in a metallic state. Sulphuretted hydrogen produces a dark brown precipitate; prussiate of potash an olive coloured; and prussiate of mercury a yellowish-white. As the last does not precipitate platina, it is an excellent test of palladium. This precipitate is from a neutral solution in nitric acid, and detonates at about 500° of Fahr. in a manner similar to gunpowder. Fluoric, arsenic, phosphoric, oxalic, tartaric, citric, and some other acids, with their salts, precipitate some of the solutions of palladium.

All the metals except gold, silver, and platina, precipitate it in the metallic state.

* PASTE. A glass made in imitation of the gems. M. Douault-Wieland has lately given the following directions for making them.

The base of all artificial stones, is a compound of silex, potash, borax, red oxide of lead, and sometimes arsenic. Pure boracic acid, and colourless quartz should be used. Hessian crucibles are better than those of porcelain. The fusion should be continued in a potter's furnace for 24 hours; the more tranquil and continued it is, the denser the paste and the greater its beauty.

Pastes.	1.	2.	3.	4.
Rock crystal,	4056 gr.	—	3456	3600
Minium,	6300	—	5328	—
Potash,	2154	1260	1944	1260
Borax,	276	360	216	360
Arsenic,	12	12	6	—
Ceruse of Clichy,	—	8508	—	8508
Sand,	—	3600	—	—

Topaz	No. 1.	No. 2.
Very white paste,	1008	3456
Glass of antimony,	43	—
Cassius purple,	1	—
Peroxide of iron (saffron of Mars),	—	36

Ruby.—Paste 2880, oxide of manganese 72. *Emerald.*—Paste 4608, green oxide of copper 42, oxide of chrome 2. *Sapphire.*—Paste 4608, oxide of cobalt 68, fused for 30 hours. *Amethyst.*—Paste 4608, oxide of manganese 36, oxide of cobalt 24, purple of Cassius 1. *Beryl.*—Paste 3456, glass of antimony 24, oxide of cobalt 1½. *Styrian, Garnet,* or ancient carbuncle.—Paste 512, glass of antimony 256, Cassius purple 2, oxide of manganese 2.

In all these mixtures, the substances should be blended by sifting, fused very carefully, and cooled very slowly, being left on the fire from 24 to 30 hours.

M. Lançon gives the following recipes:

Paste.—Litharge 100, white sand 75, potash 10. *Emerald.*—Paste 9216, acetate of copper 72, peroxide of iron 1.5. *Amethyst.*—Paste 9216, oxide of manganese from 15 to 24, oxide of cobalt 1.*

* PEARL. A highly prized spherical concretion, which is formed within certain shell-fish. It has a bluish-white colour, with considerable lustre and iridescence. It consists of alternating concentric layers of membrane and carbonate of lime. To this lamellar structure the iridescence is to be ascribed. Pearls are of course very soluble in acids.*

* PARGASITE. COMMON ACTYNOLITE.*

* PEARL ASH. An impure potash, obtained by lixiviation, from the ashes of plants.*

* PEARL SPAR. See BROWN SPAR.*

* PEARLSTONE. A sub-species of indivisible quartz of Jameson and Mohs.

Colour generally gray. Massive, vesicular, and in coarse concretions, whose surface is shining and very like pearl. In the centre of these concretions, spheres of obsidian are frequently met with. Lustre, shining. Translucent on the edges. Most easily frangible. Soft. Sp. gr. 2.24 to 2.54. Before the blow-pipe it swells, and passes into a frothy glass. Its constituents are, silica 75.25, alumina 12, oxide of iron 1.6, potash 4.5, lime 0.5, water 4.5.—*Klaproth.* It occurs in great beds in clay-porphyry near Tokay in Hungary, and near Sandy Brae in Ireland.*

* PEARL SINTER, or FIORITE. A variety of siliceous sinter. Colours white and gray. In imitative shapes. Glistening; between

resinous and pearly. In thin concentric concretions. Translucent. Scratches glass, but less hard than quartz. Brittle. Sp. gr. 1.917. It is infusible before the blow-pipe. Its constituents are, silica 94, alumina 2, lime 4. –*Santi.* It has been found on volcanic tuff on the Vicentine.*

* Peastone. A sub-species of limestone.*

* Pechblende. An ore of uranium,*

* Perchloric Acid, See Acid (Muriatic).*

Pericardium (Liquor of the). The constituents of the liquor pericardii appear to be

Water,	92.0	
Albumen,	5.5	
Mucus,	2.0	The proportion of these substances is somewhat conjectural.
Muriate of soda.	0.5	
	100.0	

* Péridot. Chrysolite.*

Perlate Salt and Acid. See Acid (Phosphoric.).

* Perlated Acid, or Ouretic. Biphosphate of soda.*

Peru (Balsam of). This substance is obtained from the myroxylon peruiferum, which grows in the warm parts of South America. The tree is full of resin, and the balsam is obtained by boiling the twigs in water. It has the consistency of honey, a brown colour, an agreeable smell, and a hot acrid taste.

Peruvian Bark. See Cinchona.

* Petalite. A mineral discovered in the mine of Uto in Sweden by M. D'Andrada, interesting, from its analysis by M. Arfwedson having led to the knowledge of a new alkali. Externally it resembles white quartz, but it has a twofold cleavage, parallel to the sides of a rhomboidal prism; two of which parallel to each other are splendent, and the other two are dull. Sp. gr. 2.45. On minute inspection, a pinkish hue may be discerned in the white colour. It scratches glass, but may be raised by a knife. It is scarcely fusible by the blow-pipe, acquiring merely a glazed surface, full of minute bubbles. When reduced to a fine powder, it appears as white as snow. Placed in nitric acid, sp. gr. 1.45, it loses its white colour, and changes to a dingy hue; the acid at the same time becomes clouded. The same acid, somewhat dilute, dissolves it without effervescence, at a boiling heat. Its constituents, by M. Arfwedson, are, silex 79.212, alumina 17.225, lithia 5.761. There is here an excess of 2.198 above the hundred parts, which M. Arfwedson says, he does not know how to account for. M. Vauquelin found 7 *per cent* of lithia, in some pure specimens of petalite which M. Berzelius sent him. Dr. Gmelin, as well as M. Arfwedson, state the sp. gr. at 2.42. Borax dissolves it with facility. The bead is transparent and colourless. Nitre, fused with pure petalite, does not betray the presence of any manganese; whence we may infer that it contains none of this metal. By Dr. Gmelin's analysis, petalite is composed of, silica 74.17, alumina 17.41, lithia 5.16, lime 0.32. moisture 2.17, and loss 0.77. He could detect no manganese in pure specimens. Those, however, of a pale rose-red colour contain it.*

Petrifactions. Stony matters, deposited either in the way of incrustation, or within the cavities of organized substances, are called petrifactions. Calcareous earth, being universally diffused and capable of solution in water, either alone, or by the medium of carbonic acid or sulphuric acid, which are likewise very abundant, is deposited whenever the water or the acid becomes dissipated. In this way we have incrustations of limestone or of selenite in the form of stalactites or dropstones from the roofs of caverns, and in various other situations.

The most remarkable observations relative to petrifactions are thus given by Kirwan:—

1. That those of shells are found on, or near, the surface of the earth; those of fish deeper; and those of wood deepest. Shells in specie are found in immense quantities at considerable depths.

2. That those organic substances that resist putrefaction most, are frequently found petrified; such as shells and the harder species of woods: on the contrary, those that are aptest to putrefy are rarely found petrified; as fish, and the softer parts of animals, &c.

3. That they are most commonly found in strata of marl, chalk, limestone, or clay, seldom in sandstone, still more rarely in gypsum; but never in gneiss, granite, basaltes, or schorl; but they sometimes occur among pyrites, and ores of iron, copper, and silver, and almost always consist of that species of earth, stone, or other mineral that surrounds them, sometimes of silex, agate, or carnelian.

4. That they are found in climates where their originals could not have existed.

5. That those found in slate or clay are compressed and flattened.

* Petroleum. See Naphtha.*

* Petrosilex. Compact feldspar.*

* Petuntse. Porcelain clay.*

Pewter, which is commonly called étain in France, and generally confounded there with true tin, is a compound metal, the basis of which is tin. The best sort consists of tin alloyed with about a twentieth, or less, of copper or other metallic bodies, as the experience of the workmen has shown to be the most conducive to the improvement of its hardness and colour, such as lead, zinc, bismuth, and antimony. There are three sorts of pewter, distinguished by the names of plate, trifle, and ley-pewter. The first was formerly much used for plates and dishes; of the second are made the pints, quarts, and other measures of beer; and of the ley-pewter, wine measures and large vessels.

The best sort of pewter consists of 17 parts of antimony to 100 parts of tin; but the French add a little copper to this kind of pewter. A very fine silver-looking metal is composed of 100 pounds of tin, eight of antimony, one of bismuth, and four of copper. On the contrary, the ley-pewter, by comparing its specific gravity with those of the mixtures of tin and lead, must contain more than a fifth part of its weight of lead.

* **Pharmacolite.** Arsenic bloom. Native arseniate of lime. See Ores.*

* **Phosphorescence.** See Light.*

* **Phosphorite.** A sub-species of apatite.

1. *Common phosphorite* Colour yellowish-white. Massive and in curved lamellar concretions. Surface drusy. Dull. Fracture uneven. Opaque. Soft and rather brittle. It melts with difficulty into a white coloured glass. When rubbed in an iron mortar, or thrown on red-hot coals, it emits a green coloured phosphoric light. Its constituents are, lime 59, phosphoric acid 34, silica 2, fluoric acid 1, oxide of iron 1.—*Pelletier.* It occurs in crusts in Estremadura in Spain.

2. *Earthy phosphorite.* Colour grayish-white. It consists of dull dusty particles. It phosphoresces on glowing coals. Its constituents are, lime 47, phosphoric acid 32.25, fluoric acid 2.25, silica 0.5, oxide of iron 0.75, water 1, mixture of quartz and loam 11.5.—*Klaproth.* It occurs in a vein at Marmarosch in Hungary. See Apatite.*

* **Phosphorus.** If phosphoric acid be mixed with 1-5th of its weight of powdered charcoal, and the mixture distilled at a moderate red heat, in a coated earthen retort, whose beak is partially immersed in a basin of water, drops of a waxy looking substance will pass over, and, falling into the water, will concrete into the solid, called phosphorus.§ It must be purified, by straining it, through a piece of chamois leather, under warm water. It is yellow and semi-transparent. It is as soft as wax, but fully more cohesive and ductile. Its sp. gr. is 1.77. It melts at 90° F. and boils at 550°.

In the atmosphere, at common temperatures, it emits a white smoke, which, in the dark, appears luminous. This smoke is acidulous, and results from the slow oxygenation of the phosphorus. In air perfectly dry, however, phosphorus does not smoke, because the acid which is formed is solid, and, closely incasing the combustible, screens it from the atmospherical oxygen.

When phosphorus is heated in the air to about 148°, it takes fire, and burns with a splendid white light, and a copious dense smoke. If the combustion take place within a large glass receiver, the smoke becomes condensed into snowy looking particles, which fall in a successive shower, coating the bottom plate with a spongy white efflorescence of phosphoric acid. This acid snow soon liquefies by the absorption of aqueous vapour from the air.

When phosphorus is inflamed in oxygen, the light and heat are incomparably more intense; the former dazzling the eye, and the latter cracking the glass vessel. Solid phosphoric acid results; consisting of 1.5 phosphorus + 2.0 oxygen.

When phosphorus is heated in highly rarefied air, three products are formed from it: one is phosphoric acid; one is a volatile white powder; and the third, is a red solid of comparative fixity, requiring a heat above that of boiling water for its fusion. The volatile substance is soluble in water, imparting acid properties to it. It seems to be phosphorous acid. The red substance is probably an oxide of phosphorus, since for its conversion into phosphoric acid, it requires less oxygen than phosphorus does. See Acids (Phosphoric, Phosphorous, and Hypophosphorous.)

Phosphorus and chlorine combine with great facility, when brought in contact with each other at common temperatures. When chlorine is introduced into a retort exhausted of air, and containing phosphorus, the phosphorus takes fire, and burns with a pale flame, throwing off sparks; while a white substance rises and condenses on the sides of the vessel.

If the chlorine be in considerable quantity, as much as 12 cubic inches to a grain of phosphorus, the latter will entirely disappear, and nothing but the white powder will be formed, into which about 9 cubic inches of the chlorine will be condensed. No new gaseous matter is produced.

The powder is a compound of phosphorus and chlorine, first described as a peculiar body by Sir H. Davy in 1810; and various analytical and synthetical experiments, which he made with it, prove that it consists of about 1 phosphorus, and 6.8 chlorine in weight. The equivalent ratio of 1 prime of the first + 2 of the second constituent, gives 1.5 to 9, or 1 to 6. It is the bichloride of phosphorus.

Its properties are very peculiar. It is snow-white, extremely volatile, rising in a gaseous form, at a temperature much below that of boiling water. Under pneumatic pressure it may be fused, and then it crystallizes in transparent prisms.

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§ M. Javal finds, that the bi-phosphate of lime, obtained by digesting 5 parts of calcined bone powder, with 2 parts of sulphuric acid, is better adapted to yield phosphorus by ignition with charcoal in a retort, than pure phosphoric acid. The latter sublimes in a great measure undecomposed.—*Ann. de Chim. et Physique.* *June* 1820.

It acts violently on water, decomposing it, whence result phosphoric and muriatic acids; the former from the combination of the phosphorus with the oxygen, and the latter from that of the chlorine with the hydrogen of the water. It produces flame when exposed to a lighted taper. If it be transmitted through an ignited glass tube, along with oxygen, it is decomposed, and phosphoric acid and chlorine are obtained. The superior fixity of the acid, above the chloride, seems to give that ascendancy of attraction to the oxygen here, which the chlorine possesses in most other cases. Dry litmus paper exposed to its vapour in a vessel exhausted of air, is reddened. When introduced into a vessel containing ammonia, a combination takes place, accompanied with much heat, and there results a compound, insoluble in water, undecomposable by acid or alkaline solutions, and possessing characters analogous to earths.

2. The protochloride of phosphorus was first obtained in a pure state, by Sir H. Davy in the year 1809. If phosphorus be sublimed through corrosive sublimate, in powder, in a glass tube, a limpid fluid comes over, as clear as water, and having a specific gravity of 1.45. It emits acid fumes when exposed to the air, by decomposing the aqueous vapour. If paper imbued with it be exposed to the air, it becomes acid without inflammation. It does not redden dry litmus paper plunged into it. Its vapour burns in the flame of a candle. When mixed with water, and heated, muriatic acid flies off, and phosphorous acid remains. See Acid (Phosphorous). If it be introduced into a vessel containing chlorine, it is converted into the bichloride; and if made to act upon ammonia, phosphorus is produced, and the same earthy-like compound results, as that formed by the bi-chloride and ammonia.

When phosphorus is gently heated in the protochloride, a part of it dissolves, and the fluid, on exposure to air, gives off acid fumes, from its action on atmospheric moisture, while a thin film of phosphorus is left behind, which usually inflames by the heat generated from the decomposition of the vapour. The first compound of this kind was obtained by MM. Gay-Lussac and Thenard, by distilling phosphorus and calomel together, in 1808; and they imagined it to be a peculiar combination of phosphorus, oxygen, and muriatic acid. No experiments have yet ascertained the quantity of phosphorus which the protochloride will dissolve. Probably, says Sir H. Davy, a definite combination may be obtained, in which the proportion of chlorine will correspond to the proportion of oxygen in the oxide of phosphorus. The subchloride would consist of 3 phosphorus + 4.5 chlorine; or of 2 + 3.

The compounds of iodine and phosphorus have been examined by Sir H. Davy, and M. Gay-Lussac.

Phosphorus unites to iodine with the disengagement of heat, but no light. One part of phosphorus and eight of iodine form a compound of a red orange-brown colour, fusible at about 212°, and volatile at a higher temperature. When brought in contact with water, phosphuretted hydrogen gas is disengaged, flocks of phosphorus are precipitated, and the water, which is colourless, contains, in solution, phosphorous and hydriodic acids.

One part of phosphorus and 16 of iodine, produce a crystalline matter of a grayish-black colour, fusible at 84°. The hydriodic acid, produced by bringing it in contact with water, is colourless, and no phosphuretted hydrogen gas is disengaged.

One part of phosphorus, and 24 of iodine, produce a black substance partially fusible at 115°. Water dissolves it, producing a strong heat, and the solution has a very deep brown colour, which is not removed by keeping it, for some time, in a gentle heat. With 1 phosphorus and 4 iodine, two compounds, very different from each other, are obtained. One of them has the same colour as that formed of 1 phosphorus + 8 iodine, and seems to be the same with it. It melts at 217.5°, and when dissolved in water, yields colourless hydriodic acid, phosphuretted hydrogen, and phosphorus, which last precipitates in orange-yellow flocks. The other compound is reddish-brown, does not melt at 212°, nor at a considerably higher temperature. Water has no sensible action on it. Potash dissolves it with the disengagement of phosphuretted hydrogen gas; and when aqueous chlorine is poured into the solution, it shows only traces of iodine. When heated in the open air, it takes fire and burns like phosphorus, emitting white vapours, without any iodine. When these vapours were condensed in a glass jar, by M. Gay-Lussac, he could perceive no iodine among them. This red substance is always obtained when the phosphorus is in the proportion of 1 to 4 of iodine. M. Gay-Lussac is inclined to consider it as identical with the red matter, which phosphorus so often furnishes, and which is at present considered as an oxide. In whatever proportions the iodide of phosphorus has been made, it exhales, as soon as it is moistened, acid vapours, owing to the hydriodic acid formed by the decomposition of the water.

Such is the account of the iodides of phosphorus given by M. Gay-Lussac. The combining ratios by theory are, for the

Subiodide, 3.0 phosphorus,	+ 15.5 iodine, or	1 + 5.16
Protiodide, 1.5	+ 15.5	1 + 10.33
Deutiodide, 1.5	+ 31.0	1 + 20.66

Phosphuretted hydrogen. Of this compound there are two varieties; one consisting of a prime of each constituent, and therefore to be called phosphuretted hydrogen; another, in which the relation of phosphorus is one-half less, to be called therefore subphosphuretted hydrogen.

1. Phosphuretted hydrogen. Into a small retort filled with milk of lime, or potash-water, let some fragments of phosphorus be introduced, and let the heat of an Argand flame be applied to the bottom of the retort, while its beak is immersed in the water of a pneumatic trough. Bubbles of gas will come over, which explode spontaneously with contact of air. It may also be procured by the action of dilute muriatic acid on phosphuret of lime. In order to obtain the gas pure, however, we must receive it over mercury. Its smell is very disagreeable. Its sp. grav. is 0.9022. 100 cubic inches weigh 27.5 gr. In oxygen, it inflames with a brilliant white light. In common air, when the gaseous bubble bursts the film of water, and explodes, there rises up a ring of white smoke, luminous in the dark. Water absorbs about 1-40th of its bulk of this gas, and acquires a yellow colour, a bitter taste, and the characteristic smell of the gas. When brought in contact with chlorine, it detonates with a brilliant green light; but the products have never been particularly examined.

By transmitting a series of electric explosions, through phosphuretted hydrogen, the phosphorus is precipitated, and hydrogen of the original gaseous volume remains. Hence the composition of the gas may be deduced from a comparison of its specific gravity with that of hydrogen.

Phosphuretted hydrogen,	0.9022
Hydrogen,	0.0694
Phos. = difference of weight,	0.8328

Thus we perceive, that this compound consists of 0.8328 phosphorus + 0.0694 hydrogen; or 12 + 1; or 1.5 + 0.125 = 1.625, which is the weight of the sum of the primes, commonly called the weight of its atom. The gas may be likewise conveniently analyzed by nitrous gas, nitrous oxide, or oxygen.

2. *Subphosphuretted hydrogen.* It was discovered by Sir H. Davy in 1812. When the crystalline hydrate of phosphorous acid is heated in a retort, out of the contact of air, solid phosphoric acid is formed, and a large quantity of subphosphuretted hydrogen is evolved. Its smell is fetid, but not so disagreeably so as that of the preceding gas. It does not spontaneously explode like it, with oxygen; but at a temperature of 300°, a violent detonation takes place. In chlorine it explodes with a white flame. Water absorbs $\frac{1}{8}$ of its volume of this gas. When potassium is heated in it, its volume is doubled, and the resulting gas is pure hydrogen. When sulphur is sublimed in 1 volume of it, a sulphuret of phosphorus is formed, and nearly 2 volumes of sulphuretted hydrogen are produced. Now as the density of vapour of phosphorus is 0.833, as appears both from the above analysis of phosphuretted hydrogen, and as also may be inferred from Sir H. Davy's equivalent prime of phosphorus, (see Acid, Phosphoric), the present gaseous compound results evidently from

$$\begin{array}{lr} \left.\begin{array}{l}\text{2 volumes of hy-}\\ \quad\text{drogen,}\end{array}\right\} = 0.0694 \times 2 = & 0.1388 \\ \left.\begin{array}{l}\text{And 1 volume}\\ \quad\text{of vapour of}\\ \quad\text{phosphorus,}\end{array}\right\} = & 0.8333 \\ \hline & 0.9721 \end{array}$$

which occupy only one volume; whence the specific gravity of this gas is 0 9721; and it consists of 2 primes of hydrogen = 0.25 + one of phosphorus = 1.5 = 1.75; being the same weight with the prime of azote.

It is probable that phosphuretted hydrogen gas sometimes contains the subphosphuret and common hydrogen mixed with it.

"There is not, perhaps," says Sir H. Davy, "in the whole series of chemical phenomena, a more beautiful illustration of the theory of definite proportions, than that offered in the decomposition of hydrophosphorous acid into phosphoric acid, and hydrophosphoric gas.

"Four proportions of the acid, contain four proportions of phosphorus and four of oxygen; two proportions of water, contain four proportions of hydrogen and two of oxygen, (all by volume). The six proportions of oxygen unite to three proportions of phosphorus to form three of phosphoric acid; and the four proportions of hydrogen combine with one of phosphorus to form one proportion of hydrophosphoric gas; and there are no other products."—*Elements*, p. 297. The reader will observe, that his hydrophosphoric gas, is our subphosphuretted hydrogen.

Phosphorus and sulphur are capable of combining. They may be united by melting them together in a tube exhausted of air, or under water. In this last case, they must be used in small quantities; as, at the moment of their action, water is decomposed, sometimes with explosions. They unite in many proportions. The most fusible compound is that of one and a half of sulphur to two of phosphorus. This remains liquid at 40° Fahrenheit. When solid its colour is yellowish-white. It is more combustible than phosphorus, and distils undecompounded at a strong heat. Had it consisted of 2 sulphur + 3 phosphorus, we should have had a definite compound of 1 prime of the first + 2 of the second constituent. This proportion forms the best composition for phosphoric fire-matches or bottles. A particle of it attached to a brimstone match, inflames when gently rubbed against a surface of cork or wood. An oxide made by heating phosphorus in a narrow mouthed phial with an ignited wire, answers the same purpose.

The phial must be kept closely corked, otherwise phosphorous acid is speedily formed.

Phosphorus is soluble in oils, and communicates to them the property of appearing luminous in the dark. Alcohol and ether also dissolve it, but more sparingly.

When swallowed in the quantity of a grain, it acts as a poison. Azote dissolves a little of it, and has its volume enlarged by about 1-40th. See Eudiometer.*

* **Phosphorus** (of Baldwin). Ignited muriate of lime.*

* **Phosphorus** (of Canton). Oyster shells calcined with sulphur.*

* **Phosphorus** (of Bologna). See Light. Sulphate of barytes.*

* **Phosphuret.** A compound of phosphorus, with a combustible or metallic oxide.*

Phlogisitcated Air. See Nitrogen.

Phlogisticated Alkali. Ferroprussiate of potash. See Acid (Prussic).

* **Phlogiston.** See Combustion.*

* **Physalite or Pyrophysalite.** Colour greenish-white. Massive. In granular concretions. Splendent in the cleavage, which is perfect, and as in topaz. Fracture uneven. Translucent on the edges. As hard as topaz. Sp. gr. 3.451. It whitens with the blow-pipe. Its constituents are, alumina 57.74, silica 34.36, fluoric acid 7.77. It is found in granite at Finbo, in Sweden. It is a sub-species of prismatic topaz.—*Jameson.**

* **Picromel.** The characteristic principle of bile. If sulphuric acid, diluted with five parts of water, be mixed with fresh bile, a yellow precipitate will fall. Heat the mixture, then leave it in repose, and decant off the clear part. What remains was formerly called resin of bile, but it is a greenish compound of sulphuric acid and picromel. Edulcorate it with water, and digest with carbonate of barytes. The picromel now liberated will dissolve in the water. On evaporating this solution, it is obtained in a solid state. Or by dissolving the green sulphate in alcohol, and digesting the solution over carbonate of potash till it cease to redden litmus paper, we obtain the picromel combined with alcohol.

It resembles inspissated bile. Its colour is greenish-yellow; its taste is intensely bitter at first, with a succeeding impression of sweetness. It is not affected by infusion of galls, but the salts of iron and subacetate of lead precipitate it from its aqueous solution. It affords no ammonia by its destructive distillation. Hence, the absence of azote is inferred, and the peculiarity of picromel.*

* **Picrotoxia.** The bitter and poisonous principle of *cocculus indicus*, the fruit of the *menispermum cocculus*. To the filtered decoction of these berries, add acetate of lead, while any precipitate falls. Filter and evaporate the liquid cautiously to the consistence of an extract. Dissolve in alcohol of 0.817, and evaporate the solution to dryness. By repeating the solutions and evaporations, we at last obtain a substance equally soluble in water and alcohol. The colouring matter may be removed by agitating it with a little water. Crystals of pure picrotoxia now fall, which may be washed with a little alcohol.

The crystals are four-sided prisms, of a white colour, and intensely bitter taste. They are soluble in 25 times their weight of water, and are not precipitable by any known re-agent. Alcohol, sp. gr. 0.810, dissolves one-third of its weight of picrotoxia. Pure sulphuric ether dissolves 2-5ths of its weight.

Strong sulphuric acid dissolves it, but not when much diluted. Nitric acid converts it into oxalic acid. It dissolves and neutralizes in acetic acid, and falls when this is saturated with an alkali. It may therefore be regarded as a vegeto-alkali itself. Aqueous potash dissolves it, without evolving any smell of ammonia. It acts as an intoxicating poison.

Sulphate of picrotoxia must be formed by dissolving picrotoxia in dilute sulphuric acid; for the strong acid chars and destroys it. The solution crystallizes on cooling. The sulphate of picrotoxia dissolves in 120 times its weight of boiling water. The solution gradually lets fall the salt in fine silky filaments disposed in bundles, and possessed of great beauty. When dry, it has a white colour, and feels elastic under the teeth, like plumose alum. It is composed of

Sulphuric acid,	9.99	5
Picrotoxia, -	90.01	45
	100.00	

Nitrate of picrotoxia. Nitric acid, of the specific gravity 1.38, diluted with twice its weight of water, dissolves, when assisted by heat, the fourth of its weight of picrotoxia. When this solution is evaporated to one-half, it becomes viscid, and on cooling, is converted into a transparent mass, similar to a solution of gum-arabic. In this state the nitrate of picrotoxia is acid, and exceedingly bitter. If it be still further dried in a temperature not exceeding 140°, it swells up, becomes opaque, and grows at last perfectly white and light, like calcined alum. If we keep it in this state, at a temperature below that of boiling water, adding a little water occasionally, the whole excess of acid exhales, and the taste become purely bitter. When this salt is washed in pure water, the acid is totally removed, and the picrotoxia is separated in the state of fine white plates.

Muriate of picrotoxia. Muriatic acid, of the specific gravity 1.145, has little action on picrotoxia. It dissolves it when assisted by heat, but does not become entirely saturated. Five parts of this acid, diluted with three times its weight of water, dissolve about one part of picrotoxia at a strong boiling temperature. The liquor, on cooling, is converted into a grayish crystalline mass, composed of confused crystals. When these crystals are well washed, they are almost destitute of taste, and feel elastic under the teeth. They dissolve in about 400 times their weight of boiling water; but are almost entirely deposited on cooling. The solubility is much increased by the presence of an excess of acid.

Acetate of picrotoxia. Acetic acid dissolves picrotoxia very well, and may be nearly saturated with it by the assistance of a boiling heat. On cooling, the acetate precipitates in well-defined prismatic needles. This acetate is soluble in 50 times its weight of boiling water. On cooling, it forms crystals of great beauty, light, without any acid smell, and much less bitter than picrotoxia itself. It is decomposed by nitric acid, which disengages the acetic acid. Dilute sulphuric acid has no marked action on it. It is not so poisonous as pure picrotoxia.—*Boullay. Ann. de Chimie.**

* Pimelite. A variety of steatite, found at Kosemuts, in Silesia.*

* Pinchbeck. An alloy of copper, in which the proportion of zinc is greater than in brass.*

* Pineal Concretions. Matter of a stony consistence is sometimes deposited in the substance of the pineal gland, formerly reckoned, from its position in the centre of the brain, to be the seat of the soul, the intellectual sanctuary. These concretions were proved by Dr. Wollaston to be phosphate of lime.*

* Pinite. Micarelle of Kirwan. Colour blackish-green. Massive, in lamellar concretions, and crystallized in an equiangular six-sided prism; in the same figure truncated or bevelled, and in a rectangular four-sided prism. Cleavage shining; lustre resinous. Fracture uneven. Opaque. Soft. Sectile; frangible, and not flexible. Feels somewhat greasy. Sp. gr. 2.95. Infusible. Its constituents are, silica 29.5, alumina 63.75, oxide of iron 6.75.—*Klaproth*. It is found in the granite of St. Michael's Mount, Cornwall; and in prophyry in Glen-Gloe and Blair-Gowrie.*

* Pistacite. See Epidote.*

* Pitch. See Bitumen.*

* Pitch Coal. See Coal.*

* Pitch Ore. See Ores of uranium.*

* Pitchstone. A sub-species of indivisible quartz. Colour green. Massive; Vitreo-resinous lustre. Feebly transparent on the edges. Fracture conchoidal. Semi-hard in a high degree. Rather easily frangible. Sp. gr. 2.2 to 2.3. It is fusible before the blowpipe. Its constituents are, silica 73, alumina 14.5, lime 1, oxide of iron 1, oxide of manganese 0.1, natron 1.75, water 8.5.—*Klaproth.* It occurs in veins that traverse granite. It is found in Arran, in Mull, Canna, Skye, and in the Townland of Newry, where it was first observed by Mr. Joy of Dublin.*

* Pitcoal. See Coal.*

* Plants. See Vegetable Kingdom.*

*Plasma. Colour between grass-green and leek-green. In angular pieces. Glistening. Fracture conchoidal. Translucent. Hard. Brittle. Sp. gr. 2.553. Infusible. Its constituents are, silica 96.75, alumina 0.25, iron 0.5, loss 2.5.—*Klaproth*. It occurs in beds associated with common calcedony. It is found also among the ruins of Rome.*

* Plaster of Paris. Gypsum.*

Platina is one of the metals for the discovery of which we are indebted to our contemporaries. Its ore has recently been found to contain, likewise, four new metals, palladium, iridium, osmium, and rhodium; which see; beside iron and chrome.

The crude platina is to be dissolved in nitro-muriatic acid, precipitated by muriate of ammonia, and exposed to a very violent heat. Then the acid and alkali are expelled, and the metal reduced in an agglutinated state, which is rendered more compact by pressure while red-hot.

Pure or refined platina is by much the heaviest body in nature. Its sp. gr. is 21.5. It is very malleable, though considerably harder than either gold or silver; and it hardens much under the hammer. Its colour on the touch-stone is not distinguishable from that of silver. Pure platina requires a very strong heat to melt it; but when urged by a white heat, its parts will adhere together by hammering. This property, which is distinguished by the name of welding, is peculiar to platina and iron, which resemble each other likewise in their infusibility.

Platina is not altered by exposure to air; neither is it acted upon by the most concentrated simple acids, even when boiling, or distilled from it.

The aqua regia best adapted to the solution of platina, is composed of one part of the nitric and three of the muriatic acid. The solution does not take place with rapidity. A small quantity of nitric oxide is disengaged, the colour of the fluid becoming first yellow, and afterward of a deep reddish-brown, which, upon dilution with water, is found to be an intense yellow. This solution is very corrosive, and tinges animal matters of a blackish-brown colour; it affords crystals by evaporation.

Count Moussin Poushkin has given the following method of preparing malleable platina:

Precipitate the platina from its solution by muriate of ammonia, and wash the precipitate with a little cold water. Reduce it in a convenient crucible to the well-known spongy metallic texture, which wash two or three times with boiling water, to carry off any portion of saline matter that may have escaped the action of the fire. Boil it for about half an hour, in as much water mixed with one-tenth part of muriatic acid as will cover the mass to the depth of about half an inch, in a convenient glass vessel. This will carry off any quantity of iron that might still exist in the metal. Decant the acid water, and edulcorate, or strongly ignite the platina.

To one part of this metal take two parts of mercury, and amalgamate in a glass or porphyry mortar. This amalgamation takes place very readily. The proper method of conducting it is to take about two drachms of mercury to three drachms of platina, and amalgamate them together; and to this amalgam may be added alternate small quantities of platina and mercury, till the whole of the two metals is combined. Several pounds may be thus amalgamated in a few hours, and in the large way a proper mill might shorten the operation.

As soon as the amalgam of platina is made, compress it in tubes of wood, by the pressure of an iron screw upon a cylinder of wood adapted to the bore of the tube. This forces the superabundant mercury from the amalgam, and renders it solid. After two or three hours, burn upon the coals, or in a crucible lined with charcoal, the sheath in which the amalgam is contained, and urge the fire to a white heat; after which the platina may be taken out in a very solid state, fit to be forged.

Muriate of tin is so delicate a test of platina, that a single drop of the recent solution of tin in muriatic acid gives a bright red colour to a solution of muriate of platina, scarcely distinguishable from water.

If the muriatic solution of platina be agitated with ether, the ether will become impregnated with the metal. This ethereal solution is of a fine pale yellow, does not stain the skin, and is precipitable by ammonia.

If the nitro-muriatic solution of platina be precipitated by lime, and the precipitate digested in sulphuric acid, a sulphate of platina will be formed. A subnitrate may be formed in the same manner. According to M. Chenevix, the insoluble sulphate contains 54.5 oxide of platina, and 45.5 acid and water; the insoluble muriate, 70 of oxide; and the subnitrate, 89 of oxide, but the purity of the oxide of platina in these is uncertain.

Platina does not combine with sulphur directly, but is soluble by the alkaline sulphurets, and precipitated from its nitro-muriatic solution by sulphuretted hydrogen.

Pelletier united it with phosphorus, by projecting small bits of phosphorus on the metal heated to redness in a crucible; or exposing to a strong heat four parts each of platina and concrete phosphoric acid with one of charcoal powder. The phosphuret of platina is of a silvery-white, very brittle, and hard enough to strike fire with steel. It is more fusible than the metal itself, and a strong heat expels the phosphorus, whence Pelletier attempted to obtain pure platina in this way. He found, however, that the last portions of phosphorus were expelled with too much difficulty.

Platina unites with most other metals. Added in the proportion of one-twelfth to gold, it forms a yellowish-white metal, highly ductile, and tolerably elastic, so that Mr. Hatchett supposed it might be used with advantage for watch-springs, and other purposes. Its specific gravity was 19.013.

Platina renders silver more hard, but its colour more dull.

Copper is much improved by alloying with platina. From 1-6th to 1-25th, or even less, renders it of a golden colour, harder, susceptible of a finer polish, smooth-grained, and much less liable to rust.

Alloys of platina with tin and lead are very apt to tarnish. See IRON.

From its hardness, infusibility, and difficulty of being acted upon by most agents, platina is of great value for making various chemical vessels. These have, it is true, the inconvenience of being liable to erosion from the caustic alkalis and some of the neutral salts.

* Platinum is now hammered in Paris into leaves of extreme thinness. By enclosing a wire of it in a little tube of silver, and drawing this through a steel plate in the usual way, Dr. Wollaston has succeeded in producing platinum wire not exceeding 1-3000th of an inch in diameter.

For some curious phenomena of its fusion, see BLOW-PIPE. There are two oxides of platinum:—

1. The protoxide may be obtained by pouring a solution of neutral nitrate of mercury into a dilute solution of muriate of platinum. A dark brown or olive-green powder falls, which is a compound of calomel and the protoxide of platinum. It must be well washed, and then gently heated so as to dissipate the mercurial salt. The pure black protoxide now remains. 100 grains of it, at a red heat, emit 12½ cubic inches of oxygen, and become metallic platinum. With enamellers' flux it may be ignited without reduction. This important fact, as well as the discovery of this oxide itself, is due to Mr. Cooper. It would thus appear that protoxide of platinum consists of

Platinum,	100.000	22.625
Oxygen,	4.423	1.000

2. The peroxide appears to contain three prime proportions. Berzelius obtained it by treating the muriate of platinum with sulphuric acid, at a distilling heat, and decomposing the sulphate by aqueous potash. The precipitated oxide is a yellowish-brown pow-

der, easily reducible by a red heat to the metallic state.

According to Mr. E. Davy, the protochloride is soluble in water; while the bichloride is insoluble. If the common nitro-muriatic solution be cautiously dried, and heated to dull redness, washed with water, and again dried, we obtain the bichloride, apparently consisting of

Platinum,	100, or	1 prime	23.73
Chlorine,	37.93	2	9.00

It has a dull olive-brown or green colour; a harsh feel; and is destitute of taste and smell. It is not fusible by heat; nor is it altered by exposure to the atmosphere. At a full red heat the chlorine flies off, and platinum remains.

According to Mr. E. Davy, there are two phosphurets and three sulphurets of platinum. See his excellent memoir in the *Phil. Mag.* vol. xl.

The salts of platinum have the following general characters:—

1. Their solution in water is yellowish-brown.
2. Potash and ammonia determine the formation of small orange-coloured crystals.
3. Sulphuretted hydrogen throws down the metal in a black powder.

Ferroprussiate of potash, and infusion of galls occasion no precipitate.

1. The sulphate of platinum may be obtained by passing a current of sulphuretted hydrogen gas through the nitro-muriatic solution. It should be washed and boiled once or twice with nitric acid, to ensure its entire conversion into sulphate. It has a brownish-black colour, and resembles the carbonaceous crust left when sugar is decomposed by heat. It is brittle, easily pulverized, and has the lustre nearly of crystallized blende. Its taste is acid, metallic, and somewhat caustic. It reddens litmus paper slightly. It is deliquescent, and soluble in water, alcohol, and ether, as well as in muriatic, nitric, and phosphoric acids. At a red heat it is resolved into metal. It appears from Mr. Davy's analysis to consist of

		Theory.
Sulphuric acid,	26.3	27.58
Protoxide of platinum,	73.7	72.42

This near coincidence is a verification of the analysis. A sulphate of potash and platinum is formed by neutralizing the sulphate with a solution of potash, and exposing the mixture for a little to a boiling heat. A granular substance resembling gunpowder is obtained. It is tasteless, insoluble in water, and possesses the lustre of blende. A soda-sulphate may be formed by a similar process; as also an ammonia-sulphate.

Fulminating platinum has been lately discovered by Mr. Edmund Davy. Into a solution of the sulphate in water, aqueous ammonia is poured, and the precipitate which falls, being washed, is put into a matrass with potash-ley, and boiled for some time. It is then filtered, washed, and dried. A brown powder is obtained, lighter than fulminating gold, which is the fulminating platinum. It explodes violently when heated to 400°; but does not detonate by friction or percussion. It is a non-conductor of electricity. With sulphuric acid it forms a deep coloured solution. Chlorine and muriatic acid gas decompose it. According to Mr. E. Davy, it consists of

		Nearly
Peroxide of platinum,	82.5	2 primes
Ammonia,	9.0	1
Water,	8.5	2

An important paper of Mr. Davy's on platinum has been recently read at the Royal Society, the details of which are not yet published.*

* PLATINUM ORE. See ORES OF PLATINUM.*

* PLEONASTE. Ceylanite.*

* PLUMBAGO. See GRAPHITE.*

* POISONS. Substances which, when applied to living bodies, derange the vital functions, and produce death, by an action not mechanical. The study of their nature, mode of operation, and antidotes, has been called *toxicology*. Poisons have been arranged into six classes:

I.—*Corrosive*, or *escharotic poisons.*

They are so named because they usually irritate, inflame, and corrode the animal texture with which they come into contact. Their action is in general more violent and formidable than that of the other poisons. The following list from Orfila contains the principal bodies of this class:

1. *Mercurial preparations;* corrosive sublimate; red oxide of mercury; turpeth mineral, or yellow subsulphate of mercury; pernitrate of mercury; mercurial vapours.
2. *Arsenical preparations;* such as white oxide of arsenic, and its combinations with the bases, called arsenites; arsenic acid, and the arseniates; yellow and red sulphuret of arsenic; black oxide of arsenic, or fly-powder.
3. *Antimonial preparations;* such as tartar emetic, or cream-tartrate of antimony; oxide of antimony; kermes mineral; muriate of antimony; and antimonial wine.
4. *Cupreous preparations;* such as verdigris; acetate of copper; the cupreous sulphate, nitrate, and muriate; ammoniacal copper; oxide of copper; cupreous soaps, or grease tainted with oxide of copper; and cupreous wines or vinegars.
5. *Muriate of tin.*
6. *Oxide and sulphate of zinc.*
7. *Nitrate of silver.*
8. *Muriate of gold.*
9. *Pearl-white* or *the oxide of bismuth*, and the subnitrate of this metal.
10. *Concentrated acids;* sulphuric, nitric, phosphoric, muriatic, hydriodic, acetic, &c.

11. *Corrosive alkalis*, pure or subcarbonated potash, soda, and ammonia.

12. The *caustic earths*, lime and barytes.

13. *Muriate and carbonate of barytes.*

14. *Glass and enamel powder.*

15. *Cantharides.*

II.—*Astringent poisons.*

1. *Preparations of lead*, such as the acetate, carbonate, wines sweetened with lead, water impregnated with its oxide, food cooked in vessels containing lead, sirups clarified with subacetate of lead, plumbean vapours.

III —*Acrid poisons.*

1. The *gases;* chlorine, muriatic acid, sulphurous acid, nitrous gas, and nitro-muriatic vapours.

2. Jatropha manihot, the fresh root, and its juice, from which cassava is made.

3. *The Indian ricinus*, or Molucca wood.

4. *Scammony*. 5. Gamboge. 6. Seeds of *palma Christi*. 7. Elaterium. 8 Colocynth. 9. White hellebore root. 10. Black hellebore root. 11. Seeds of stavesacre. 12. The wood and fruit of the *ahoväi* of Brazil. 13. Rhododendron chrysanthum. 14. Bulbs of *colchicum*, gathered in summer and autumn. 15. The milky juice of the convolvulus arvensis, 16. Asclepias. 17. Œnanthe fistulosa and crocata. 18. Some species of *clematis*. 19. Anemone pulsatilla. 20. Root of Wolf's-bane. 21. Fresh roots of Arum maculatum. 22. Berries and bark of Daphne Mezereum. 23. The plant and emanations of the rhus toxicodendron. 24. Euphorbia Officinalis. 25. Several species of ranunculus, particularly the aquatilis. 26. Nitre, in a large dose. 27. Some muscles and other shell-fish.

IV.—*Narcotic and stupefying poisons.*

1. The *gases;* hydrogen, azote, and oxide of azote.

2. Poppy and opium.

3. The roots of the solanum somniferum; berries and leaves of the solanum nigrum; those of the morel with yellow fruit. 4. The roots and leaves of the atropa mandragora. 5. Datura stramonium. 6. Hyosciamus, or henbane. 7. Lactuca virosa. 8. Paris quadrifolia, or herb Paris. 9. Lauro-cerasus, or bay laurel and prussic acid. 10. Berries of the yew tree. 11. Ervum ervilia; the seeds. 12. The seeds of lathyrus cicera. 13. Distilled water of bitter almonds. 14. The effluvia of many of the above plants.

V.—*Narcotico-acrid poisons.*

1. Carbonic acid; the gas of charcoal stoves and fermenting liquors. 2. The manchineel. 3. Faba Sancti Ignatii. 4. The exhalations and juice of the poison-tree of Macassar, or Upas-Antiar. 5. The ticunas. 6. Certain species of Strychnos. 7. The whole plant, Lauro-cerasus. 8. Belladona, or deadly nightshade. 9. Tobacco. 10. Roots of white bryony. 11. Roots of the Chœrophyllum silvestre. 12. Conium maculatum, or spotted hemlock. 13. Æthusa cynapium. 14. Cicuta virosa. 15. Anagallis arvensis. 16. Mercurialis perennis. 17. Digitalis purpurea. 18. The distilled waters and oils of some of the above plants. 19. The odorant principle of some of them. 20. Woorara of Guiana. 21. Camphor. 22. Cocculus Indicus. 23. Several mushrooms; see AGARICUS, and BOLETUS. 24. Secale cornutum. 25. Lolium temulentum. 26. Sium latifolium. 27. Coriaria myrtifolia.

VI.—*Septic* or *putrescent poisons.*

1. Sulphuretted hydrogen. 2. Putrid effluvia of animal bodies. 3. Contagious effluvia, or formites and miasmata; see MIASMATA. 4. Venomous animals; the viper, rattlesnake, scorpion, mad dog, &c.

I regret that the limits of this work preclude me from introducing a systematic view of the mode of action of the principal substances in the above catalogue. Under *Antimony*, *Arsenic*, *Copper*, *Lead*, *Mercury*, *Silver*, pretty copious details are given of the poisonous effects of their preparations, and of the best methods of counteracting them.

Antidote for vegetable poisons. M. Drapiez has ascertained, by numerous experiments, that the fruit of the *feuillea cordifolia*, is a powerful antidote against vegetable poisons. He poisoned dogs with the rhus toxicodendron, hemlock, and nux vomica; and all those which were left to the effects of the poison died, but those to which the above fruit was administered, recovered completely, after a short illness. To see whether the antidote would act in the same way, applied externally to wounds into which vegetable poisons had been introduced, he took two arrows, which had been dipped into the juice of the *manchenille*, and slightly wounded with them two cats; to one of these wounds he applied a poultice, composed of the fruit of the *feuillea cordifolia*, while the other was left without any application. The former suffered no inconvenience, except from the pain of the wound, which speedily healed; while the other, in a short time, fell into convulsions, and died. This fruit loses these valuable virtues, if kept two years after it is gathered.

Dr. Chisholm states, that the juice of the sugar-cane is the best antidote for arsenic.

Dr. Lyman Spalding of New York announces in a small pamphlet, that for above these fifty years, the *Scutellaria Lateriflora* has proved to be an infallible means for the prevention and cure of the hydrophobia after the bite of rabid animals. It is better applied as a dry powder, than fresh. According to the testimonies of several American physicians, this plant, not yet received as a remedy in any European *Materia Medica*, afforded perfect relief in above a thousand cases, as well in the human species, as in the brute creation, (dogs, swine, and oxen).—*Phil. Mag.* lvi. p. 151.*

* **Polishing-Slate.** See Clay.*

* **Pollen.** The powdery matter evolved from the *antheræ* of flowers. That of the date seems, from the experiments of Fourcroy and Vauquelin, to approach in its constitution to animal substances; that of the hazel-nut contains tannin, resin, much gluten, and a little fibrin; and that of the tulip yielded to Grotthus the following constituents in 26 parts:

Vegetable albumen, -	20.25
Malate of lime, with trace of malate of magnesia,	3.50
Malic acid, - - - -	1.00
Malate of ammonia, Colouring matter, Saltpetre? .	1.25
	26.00

The principle in pollen, intermediate between gluten and albumen, has been named by Dr. John, *Pollenin*.

It is yellow, without taste and smell; insoluble in water, alcohol, ether, fat, and volatile oils, and petroleum.

It burns with flame. On exposure to air, it assumes the smell and taste of cheese, and soon becomes putrid with disengagement of ammonia.*

* **Polychroite.** The colouring matter of saffron.*

* **Pompholix.** White oxide of zinc.*

* **Ponderous Spar.** See Heavy Spar.*

* **Porcelain Earth.** See Clay.*

Porcelain is the most beautiful and the finest of all earthen wares.

The art of making porcelain is one of those in which Europe has been excelled by oriental nations. The first porcelain that was seen in Europe was brought from Japan and China. The whiteness, transparency, fineness, neatness, elegance, and even the magnificence of this pottery, which soon became the ornament of sumptuous tables, did not fail to excite the admiration and industry of Europeans.

Father Entrecolles, missionary at China, sent home a summary description of the process by which the inhabitants of that country make their porcelain, and also a small quantity of the materials which they employ in its composition. He said, that the Chinese composed their porcelain of two ingredients, one of which is a hard stone or rock, called by them petuntse, which they carefully grind to a very fine powder; and the other, called by them kaolin, is a white earthy substance, which they mix intimately with the ground petuntse.

Reaumur examined both these matters; and having exposed them separately to a violent fire, he discovered, that the petuntse had fused without addition, and that the kaolin had given no sign of fusibility. He afterward mixed these matters, and formed cakes of them, which, by baking, were converted into porcelain similar to that of China. See Kaolin, Petuntse, and Pottery.

Porcelain of Reaumur. Reaumur gave the quality of porcelain to glass; that is, he rendered glass of a milky colour, semi-transparent, so hard as to strike fire with steel, infusible, and of a fibrous grain, by means of cementation. The process which he published is not difficult. Common glass, such as that of which wine bottles are made, succeeds best. The glass vessel which is to be converted into porcelain, is to be enclosed in a baked earthen case or seggar. The vessel and case are to be filled with a cement composed of equal parts of sand and powdered gypsum or plaster; and the whole is to be put into a potter's kiln, and to remain there during the baking of common earthenware; after which the glass vessel will be found transformed into such a matter as has been described.

* **Porphyry** is a compound rock, having a basis, in which the other contemporaneous constituent parts are imbedded. The base is sometimes clay-stone, sometimes hornstone, sometimes compact feldspar; or pitchstone, pearlstone, and obsidian. The imbedded parts are most commonly feldspar and quartz, which are usually crystallized, more or less perfectly, and hence they appear sometimes granular. According to Werner, there are two distinct porphyry formations; the oldest occurs in gneiss, in beds of great magnitude; and also in mica-slate and clay-slate. Between Blair in Athole and Dalnacardoch, there is a very fine example of a bed of porphyry-slate in mica. The second porphyry formation is much more widely extended. It consists principally of clay porphyry, while the former consists chiefly of hornstone porphyry and feldspar porphyry.

It sometimes contains considerable repositories of ore, in veins. Gold, silver, lead, tin, copper, iron, and manganese occur in it; but chiefly in the newer porphyry, as happens with the Hungarian mines. It occurs in Arran, and in Perthshire, between Dalnacardoch and Tummel-bridge.*

Portland Stone. A compact sandstone from the Isle of Portland. The cement is calcareous.

* **Potash**, commonly called the vegetable alkali, because it is obtained in an impure state by the incineration of vegetables. It is the hydrated deutoxide of potassium.*

Table of the saline product of one thousand lbs. of ashes of the following vegetables:— Saline products.

Stalks of Turkey wheat or mais,	198 lbs.
Stalks of sunflower,	349
Vine-branches,	162.6
Elm,	166
Box,	78

Sallow,	102	
Oak,	111	
Aspen,	61	
Beech,	219	
Fir,	132	
Fern cut in August,	116	or 125 according to Wildenheim.
Wormwood,	748	
Fumitory,	360	
Heath,	115	Wildenheim.

On these tables Kirwan makes the following remarks :—

1. That in general weeds yield more ashes, and their ashes much more salt than woods; and that consequently, as to salts of the vegetable alkali kind, as potash, pearl ash, cashup, &c. neither America, Trieste, nor the northern countries, have any advantage over Ireland.

2. That of all weeds fumitory produces most salt, and next to it wormwood. But if we attend only to the quantity of salt in a given weight of ashes, the ashes of wormwood contain most. Trifolium fibrinum also produces more ashes and salt than fern.

The process for obtaining pot and pearlash is given by Kirwan, as follows :—

1. The weeds should be cut just before they seed, then spread, well dried, and gathered clean.

2. They should be burned within doors on a grate, and the ashes laid in a chest as fast as they are produced. If any charcoal be visible, it should be picked out, and thrown back into the fire. If the weeds be moist, much coal will be found. A close smothered fire, which has been recommended by some, is very prejudicial.

3. They should be lixiviated with twelve times their weight of boiling water. A drop of the solution of corrosive sublimate will immediately discover when the water ceases to take up any more alkali. The earthy matter that remains is said to be a good manure for clayey soils.

4. The ley thus formed should be evaporated to dryness in iron pans. Two or three at least of these should be used, and the ley, as fast as it is concreted, passed from the one to the other. Thus, much time is saved, as weak leys evaporate more quickly than the stronger. The salt thus procured is of a dark colour, and contains much extractive matter, and being formed in iron pots, is called potash.

5. This salt should then be carried to a reverberatory furnace, in which the extractive matter is burnt off, and much of the water dissipated: hence it generally loses from ten to fifteen per cent of its weight. Particular care should be taken to prevent its melting, as the extractive matter would not then be perfectly consumed, and the alkali would form such a union with the earthy parts as could not easily be dissolved. Kirwan adds this caution, because Dr. Lewis and Mr. Dossie have inadvertently directed the contrary. This salt thus refined is called pearl-ash, and must be the same as the Dantzic pearl-ash.

To obtain this alkali pure, Berthollet recommends to evaporate a solution of potash, made caustic by boiling with quicklime, till it becomes of a thickish consistence, to add about an equal weight of alcohol, and let the mixture stand some time in a close vessel. Some solid matter, partly crystallized, will collect at the bottom; above this will be a small quantity of a dark coloured fluid, and on the top another lighter. The latter, separated by decantation, is to be evaporated quickly in a silver basin in a sand heat. Glass, or almost any other metal, would be corroded by the potash. Before the evaporation has been carried far, the solution is to be removed from the fire, and suffered to stand at rest; when it will again separate into two fluids. The lighter, being poured off, is again to be evaporated with a quick heat; and on standing a day or two in a close vessel, it will deposite transparent crystals of pure potash. If the liquor be evaporated to a pellicle, the potash will concrete without regular crystallization. In both cases a high-coloured liquor is separated, which is to be poured off; and the potash must be kept carefully secluded from air.

A perfectly pure solution of potash, will remain transparent, on the addition of lime-water, show no effervescence with dilute sulphuric acid, and not give any precipitate on blowing air from the lungs through it by means of a tube.

* Pure potash for experimental purposes, may most easily be obtained by igniting cream of tartar in a crucible, dissolving the residue in water, filtering, boiling with a quantity of quicklime, and after subsidence, decanting the clear liquid, and evaporating in a loosely covered silver capsule, till it flows like oil, and then pouring it out on a clean iron plate. A solid white cake of pure hydrate of potash is thus obtained, without the agency of alcohol. It must be immediately broken into fragments, and kept in a well-stoppered phial.

As 100 parts of subcarbonate of potash are equivalent to about 70 of pure concentrated oil of vitriol, if into a measure tube, graduated into 100 equal parts, we introduce the 70 grains of acid, and fill up the remaining space with water, then we have an alkalimeter for estimating the value of commercial pearl ashes, which, if pure, will require for 100 grains one hundred divisions of the liquid to neutralize them. If they contain only 60 per cent of genuine subcarbonate, then 100 grains will require only 60 divisions, and so on. When the alkalimeter indications are required in pure or absolute potash, such as constitutes the basis of nitre, then we must use 102 grains of pure oil of vitroil, along with the requisite bulk of water to fill up the volume of the graduated tube.

The hydrate of potash, as obtained by the preceding process, is solid, white, and extremely caustic; in minute quantities, changing the purple of violets and cabbage to a green, reddened litmus to purple, and yellow tumeric to a reddish-brown. It rapidly attracts humidity from the air, passing into the oil of tartar *per deliquium* of the old chemists; a name, however, also given to the deliquesced subcarbonate. Charcoal applied to the hydrate of potash at a cherry-red heat, gives birth to carburetted hydrogen, and an alkaline subcarbonate; but at a heat bordering on whiteness, carburetted hydrogen, carbonous oxide, and potassium, are formed. Several metals decompose the hydrate of potash, by the aid of heat; particularly potassium, sodium, and iron. The fused hydrate of potash consists of 5.95 deutoxide of potassium + 1.125 water = 7.075, which number represents the compound prime equivalent. It is used in surgery, as the potential cautery for forming eschars; and it was formerly employed in medicine diluted with broths as a lithontriptic. In chemistry, it is very extensively employed, both in manufactures and as a reagent in analysis. It is the basis of all the common soft soaps. The oxides of the following metals are soluble in aqueous potash:—Lead, tin, nickel, arsenic, cobalt, manganese, zinc, antimony, tellurium, tungsten, molybdenum. For the sulphuret, see SULPHUR.*

* **POTASSIUM.** If a thin piece of solid hydrate of potash, be placed between two discs of platinum, connected with the extremities of a voltaic apparatus of 200 double plates, four inch square, it will soon undergo fusion; oxygen will separate at the positive surface, and small metallic globules will appear at the negative surface. These form the marvellous metal potassium, first revealed to the world by Sir H. Davy, early in October 1807.

If iron turnings be heated to whiteness in a curved gun-barrel, and potash be melted and made slowly to come in contact with the turnings, air being excluded, potassium will be formed, and will collect in the cool part of the tube. This method of procuring it was discovered by MM. Gay-Lussac and Thenard, in 1808. It may likewise be produced, by igniting potash with charcoal, as M. Curaudau showed the same year.

Potassium is possessed of very extraordinary properties. It is lighter than water; its sp. gr. being 0.865 to water 1.0. At common temperatures, it is solid, soft, and easily moulded by the fingers. At 150° F. it fuses, and in a heat a little below redness, it rises in vapour. It is perfectly opaque. When newly cut, its colour is splendent white, like that of silver, but it rapidly tarnishes in the air. To preserve it unchanged, we must enclose it in a small phial, with pure naphtha. It conducts electricity like the common metals. When thrown upon water, it acts with great violence, and swims upon the surface, burning with a beautiful light of a red colour, mixed with violet. The water becomes a solution of pure potash. When moderately heated in the [illegible] it inflames, burns with a red light, and throws off alkaline fumes. Placed in chlorine, it spontaneously burns with great brilliancy.

On all fluid bodies which contain water, or much oxygen or chlorine, it readily acts; and in its general powers of chemical combination, says its illustrious discoverer, potassium may be compared to the alkahest, or universal solvent, imagined by the alchemists.

Potassium combines with oxygen, in different proportions. When potassium is gently heated in common air or in oxygen, the result of its combustion is an orange-coloured fusible substance. For every grain of the metal consumed, about $1\frac{7}{10}$ cubic inches of oxygen are condensed. To make the experiment accurately, the metal should be burned in a tray of platina covered with a coating of fused muriate of potash.

The substance procured by the combustion of potassium at a low temperature, was first observed in October 1807, by Sir H. Davy, who supposed it to be the protoxide; but MM. Gay-Lussac and Thenard, in 1810, showed, that it was in reality the deutoxide or peroxide. When it is thrown into water, oxygen is evolved, and a solution of the protoxide results, constituting common aqueous potash. When it is fused, and brought in contact with combustible bodies, they burn vividly, by the excess of its oxygen. If it be heated in carbonic acid, oxygen is disengaged, and common subcarbonate of potash is formed.

When it is heated very strongly upon platina, oxygen gas is expelled from it, and there remains a difficultly fusible substance of a gray colour, vitreous fracture, soluble in water, without effervescence, but with much heat. Aqueous potash is produced. The above ignited solid, is protoxide of potassium, which becomes pure potash by combination with the equivalent quantity of water. When we produce potassium with ignited iron turnings and potash, much hydrogen is disengaged from the water of the hydrate, while the iron becomes oxidized from the residuary oxygen. By heating together pure hydrate of potash and boracic acid, Sir H. Davy obtained from from 17 to 18 of water, from 100 parts of the solid alkali.

By acting on potassium with a very small quantity of water, or by heating potassium with fused potash, the protoxide may also be obtained. The proportion of oxygen in the protoxide, is determined by the action of potassium upon water. 8 grains of potassium produce from water about 9½ cubic inches of hydrogen; and for these the metal must have fixed 4¾ cubic inches of oxygen. But as 100 cubic inches of oxygen weigh 33.9 gr. 4¾ will weigh 1.61. Thus, 9.61 gr. of the protoxide will contain 8 of metal; and 100 will contain 83.25 metal + 16.75 oxygen. From these data, the prime of potassium comes out 4.969; and that of the protoxide 5.969. Sir H. Davy adopts the number 75 for potassium, corresponding to 50 on the oxygen scale.

When potassium is heated strongly in a small quantity of common air, the oxygen of which is not sufficient for its conversion into potash, a substance is formed of a grayish colour, which, when thrown into water, effervesces without taking fire. It is doubtful, whether it be a mixture of the protoxide and potassium, or a combination of potassium with a smaller proportion of oxygen than exists in the protoxide. In this case, it would be a suboxide, consisting of 2 primes of potassium = 10 + 1 of oxygen = 1.

When thin pieces of potassium are introduced into chlorine, the inflammation is very vivid; and when potassium is made to act on chloride of sulphur, there is an explosion. The attraction of chlorine for potassium is much stronger than the attraction of oxygen for the metal. Both of the oxides of potassium are immediately decomposed by chlorine, with the formation of a fixed chloride, and the extrication of oxygen.

The combination of potassium and chlorine, is the substance which has been improperly called muriate of potash, and which, in common cases, is formed, by causing liquid muriatic acid to saturate solution of potash, and then evaporating the liquid to dryness and igniting the solid residuum. The hydrogen of the acid here unites to the oxygen of the alkali, forming water, which is exhaled; while the remaining chlorine and potassium combine. It consists of 5 potassium + 4.5 chlorine.

Potassium combines with hydrogen, to form potassuretted hydrogen, a spontaneously inflammable gas, which comes over occasionally in the production of potassium by the gun-barrel experiment. MM. Gay-Lussac and Thenard describe also a solid compound of the same two ingredients, which they call a hydruret of potassium. It is formed by heating the metal a long while in the gas, at a temperature just under ignition. They describe it as a grayish solid, giving out its hydrogen on contact with mercury.

When potassium and sulphur are heated together, they combine with great energy, with disengagement of heat and light, even *in vacuo*. The resulting sulphuret of potassium is of a dark gray colour. It acts with great energy on water, producing sulphuretted hydrogen, and burns brilliantly when heated in the air, becoming sulphate of potash. It consists of 2 sulphur + 5 potassium, by Sir H. Davy's experiments. Potassium has so strong an attraction for sulphur, that it rapidly separates it from hydrogen. If the potassium be heated in the sulphuretted gas, it takes fire and burns with great brilliancy; sulphuret of potassium is formed, and pure hydrogen is set free.

Potassium and phosphorus enter into union with the evolution of light; but the mutual action is feebler than in the preceding compound. The phosphuret of potassium, in its common form, is a substance of a dark chocolate colour; but when heated with potassium in great excess, it becomes of a deep gray colour, with considerable lustre. Hence, it is probable, that phosphorus and potassium are capable of combining in two proportions. The phosphuret of potassium burns with great brilliancy, when exposed to air, and when thrown into water produces an explosion, in consequence of the immediate disengagement of phosphuretted hydrogen.

Charcoal which has been strongly heated in contact with potassium, effervesces in water, rendering it alkaline, though the charcoal may be previously exposed to a temperature at which potassium is volatilized. Hence, there is probably a compound of the two formed by a feeble attraction.

Of all known substances, potassium is that which has the strongest attraction for oxygen; and it produces such a condensation of it, that the oxides of potassium are denser than the metal itself. Potassium has been skilfully used by Sir H. Davy and MM. Gay-Lussac and Thenard, for detecting the presence of oxygen in bodies. A number of substances, indecomposable by other chemical agents, are readily decomposed by this substance.—*Elements of Chemical Phil. by Sir H. Davy.*

* POTASSIUM, (IODIDE OF.) See ACID (HYDRIODIC.)*

POTTERY. The art of making pottery is intimately connected with chemistry, not only from the great use made of earthen vessels by chemists, but also because all the processes of this art, and the means of perfecting it, are dependent on chemistry.

The process of manufacturing stoneware, according to Dr. Watson, is as follows:

Tobacco-pipe clay from Dorsetshire is beaten much in water. By this process, the finer parts of the clay remain suspended in the water, while the coarser sand and other impurities fall to the bottom. The thick liquid, consisting of water and the finer parts of the clay, is farther purified by passing it through hair and lawn sieves, of different degrees of fineness. After this, the liquid is mixed (in various proportions for various wares), with another liquor, of as nearly as may be the same density, and consisting of flints, calcined, ground, and suspended in water. The mixture is then dried in a kiln; and being afterward beaten to a proper temper, it becomes fit for being formed at the wheel into dishes, plates, bowls, &c. When this ware is to be put into the furnace to be baked, the several pieces of it are placed in the cases made of clay, called seggars, which are piled one upon another, in the dome of the furnace. A fire is then lighted; and when the ware is brought to a proper temper, which happens in about forty-eight hours, it is glazed by common salt. The salt is thrown into the furnace, through holes in the upper part of it, by the heat of which it is instantly converted into a thick vapour; which, circulating through the furnace, enters the seggar through holes made in its side, (the top being covered to prevent the salt from falling on the ware); and attaching itself to the surface of the ware, it forms that vitreous coat upon the surface which is called its glaze.

The yellow or queen's-ware is made of the same materials as the flint-ware; but the proportion in which the materials are mixed is not the same, nor is the ware glazed in the same way. The flint-ware is generally made of four measures of liquid flint, and of eighteen of liquid clay. The yellow ware has a greater proportion of clay in it. In some manufactories they mix 20, and in others 24 measures of clay, with 4 of flint. These proportions, if estimated by the weight of the materials, would probably give for the flint-ware about 3 cwt. of clay to 1 cwt. of flint, and for the yellow ware somewhat more clay. The proportion, however, for both sorts of ware depends very much upon the nature of the clay, which is very variable even in the same pit. Hence a previous trial must be made of the quality of the clay, by burning a kiln of the ware. If there be too much flint mixed with the clay, the ware, when exposed to the air after burning, is apt to crack; and if there be too little, the ware will not receive the proper glaze from the circulation of the salt vapour.

This glaze, even when it is most perfect, is in appearance less beautiful than the glaze on the yellow ware.

The yellow glaze is made by mixing together in water, till it becomes as thick as cream, 112 lb. of white lead, 24 lb. of ground flint, and 6 lb. of ground flint-glass. Some manufactories leave out the glass, and mix only 80 lb. of white lead with 20 lb. of ground flint; and others doubtless observe different rules, of which it is very difficult to obtain an account.

The ware before it is glazed is baked in the fire. By this means it acquires the property of strongly imbibing moisture. It is therefore dipped in the liquid glaze, and suddenly taken out: the glaze is imbibed into its pores, and the ware presently becomes dry. It is then exposed a second time to the fire, by which means the glaze it has imbibed is melted, and a thin glassy coat is formed upon its surface. The colour of this coat is more or less yellow, according as a greater or less proportion of lead has been used. The lead is principally instrumental in producing the glaze, as well as in giving it the yellow colour; for lead, of all the substances hitherto known, has the greatest power of promoting the vitrification of the substances with which it is mixed. The flint serves to give a consistence to the lead during the time of its vitrification, and to hinder it from becoming too fluid, and running down the sides of the ware, and thereby leaving them unglazed.

The yellowish colour which lead gives when vitrified with flints, may be wholly changed by very small additions of other mineral substances. Thus, to give one instance, the beautiful black glaze, which is fixed on one sort of the ware made at Nottingham, is composed of 21 parts by weight of white lead, of five of powdered flints and of 3 of manganese. The queen's-ware at present is much whiter than formerly.

The coarse stone ware made at Bristol consists of tobacco-pipe clay and sand, and is glazed by the vapour of salt, like Staffordshire flint-ware; but it is far inferior to it in beauty.

* POTENTIAL CAUTERY. Caustic potash.*

* POTSTONE, *or* LAPIS OLLARIS. Colour greenish-gray. Massive, and in granular concretions. Glistening. Fracture curved foliated. Translucent on the edges. Streak white. Soft. Sectile. Feels greasy. Somewhat tough. Sp. gr. 2.8. Its constituents are, silica 39, magnesia 16, oxide of iron 10, carbonic acid 20, water 10. It occurs in thick beds in primitive slate. It is found abundantly on the shores of the lake Como in Lombardy. It is fashioned into culinary vessels in Greenland. It is a sub-species of the rhomboidal mica of Professor Jameson.*

* POWDER OF ALGOROTH. The white oxide of antimony, thrown down from the muriate by water.*

* PRASE. Colour leek-green. Massive, seldom crystallized. Its forms are, the sixsided prism, and the sixsided pyramid. Lustre shining. Fracture conchoidal. Translucent. Hard. Tough. Sp. gr. 2.67. Its constituents are, silica 98.5, alumina, with magnesia, 0.5, and oxide of iron 1.—*Bucholz*. It occurs in mineral beds composed of magnetic ironstone, galena, &c. It is found in the island of Bute, and in Borrodale.*

* PRECIPITANTS. See METALS, and MINERAL WATERS.*

PRECIPITATE, *and* PRECIPITATION. When

a body dissolved in a fluid is either in whole or in part made to separate and fall down in the concrete state, this falling down is called precipitation, and the matter thus separated is called a precipitate. See WATERS (MINERAL,) and METALS.

* **PRECIPITATE**, *per se*. Red oxide of mercury, by heat.*

* **PREHNITE**. Prismatic prehnite; of which there are two sub-species, the foliated and the fibrous.

1. *Foliated*. Colour apple-green. Massive, in distinct concretions, and sometimes crystallized. The primitive form is an oblique four-sided prism of 103° and 77°. The secondary forms are, an oblique four-sided table, and irregular eight-sided table, an irregular six-sided table, and a broad rectangular four-sided prism. Shining. Fracture fine grained uneven. Translucent. Hardness from feldspar to quartz. Easily frangible. Sp. gr. 2.8 to 3.0. It melts with intumescence into a pale-green or yellow glass. It does not gelatinize with acids. Its constituents are, silica 43.83, alumina 30.33, lime 18.33, oxide of iron 5.66, water 1.83.—*Klaproth*. It occurs in France, in the Alps of Savoy, and in the Tyrol. It is said to become electric by heating. Beautiful varieties are found in the interior of Southern Africa.

2. *Fibrous Prehnite*. Colour siskin-green. Massive, in distinct concretions, and crystallized in acicular four-sided prisms. Glistening, pearly. Translucent. Easily frangible. Sp. gr. 2.89. It melts into a vesicular enamel. It becomes electric by heating. Its constituents are, silica 42.5, alumina 28.5, lime 20.44, natron and potash 0.75, oxide of iron 3, water 2.—*Laugier*. It occurs in veins and cavities in trap-rocks near Beith in Ayrshire, Bishoptown in Renfrewshire, at Hartfield near Paisley, and near Frisky-hall, Old Kilpatrick; in the trap-rocks round Edinburgh, &c.*

* **PRINCE'S METAL**. A species of copper alloy, in which the proportion of zinc is more considerable than in brass.*

* **PROSTATE CONCRETIONS**. See CALCULI.*

* **PRUSSIAN ALKALI**. See ACID (FERROPRUSSIC.)*

* **PRUSSIAN BLUE**. See IRON and the above ACID.*

* **PRUSSIC ACID**. See ACID (PRUSSIC.)*

* **PRUSSINE**, or **PRUSSIC GAS**, the cyanogen of M. Gay-Lussac. This last term signifies the producer of blue. But the production of blue is never the result of the direct action of this substance on any other single body; but an indirect and unexplained operation of it in conjunction with iron, hydrogen and oxygen. The same reason which leads to the term cyanogen, would warrant us in calling it leucogen, erythrogen, or chlorogen; for it produces white, red, or green, with other metals, if it produce blue with iron. Although, therefore, the highest deference be due to the nomenclature of so distinguished a chemist as M. Gay-Lussac, yet I apprehend it is better to retain the old word, connected merely with the history of the substance. As cyanogen, like chlorine and iodine, by its action on potassium, produces flame, and like them is acidified by hydrogen, I would respectfully propose the name PRUSSINE. Its discovery and investigation do the highest honour to to M. Gay-Lussac.

Prussine, or cyanogen, is obtained by decomposing the prusside or cyanide of mercury by heat: But as the prusside of mercury varies in its composition, we shall begin by describing its formation.

By digesting red oxide of mercury with prussian blue and hot water, we obtain a cyanide perfectly neutral, which crystallizes in long four-sided prisms, truncated obliquely. By repeated solutions and crystallizations, we may free it from a small portion of adhering iron. But M. Gay-Lussac prefers boiling it with red oxide of mercury, which completely precipitates the oxide of iron, and he then saturates the excess of oxide of mercury, with a little prussic acid, or a little muriatic acid. The prusside thus formed, is decomposed by heat, to obtain the radical. For common experiments, we may dispense with these precautions.

When this cyanide is boiled with red oxide of mercury, it dissolves a considerable quantity of the oxide, becomes alkaline, crystallizes no longer in prisms, but in small scales, and its solubility in water appears a little increased. When evaporated to dryness, it is very easily charred, which obliges us to employ the heat merely of a water bath. This compound was observed by M. Proust. When decomposed by heat, it gives abundance of prussine, but mixed with carbonic acid gas. Proust says, that it yields ammonia, oil in considerable abundance, carbonic acid, azote, and oxide of carbon. He employed a moist prusside. Had it been dry, the discovery of prussine could hardly have escaped him. The prusside of mercury, when neutral and quite dry, gives nothing but prussine; when moist, it furnishes only carbonic acid, ammonia, and a great deal of prussic acid vapour. When we employ the prusside made with excess of peroxide, the same products are obtained, but in different proportions, along with azote, and a brown liquid, which Proust took for an oil, though it is not one in reality. Hence to obtain pure prussine, we must employ the neutral prusside in a state of perfect dryness. The other mercurial compound is not, however, simply a sub-prusside. It is a compound of oxide of mercury, and the prusside, analogous to the brick coloured precipitate obtained by adding a little potash to the solution of deutochloride of mercury (corrosive sublimate,) which is a triple compound of chlorine, oxygen, and mercury, or a binary compound of oxide of mercury, with the chloride of that metal. These compounds might be called, oxyprusside and oxychloride of mercury.

When the simple mercurial prusside is exposed to heat in a small glass retort, or tube, shut at one extremity, it soon begins to blacken. It appears to melt like an animal matter, and then the prussine is disengaged in abundance. This gas is pure from the beginning of the process to the end, provided always that the heat be not very high; for if it were sufficiently intense to melt the glass, a little azote would be evolved. Mercury is volatilized with a considerable quantity of prusside, and there remains a charry matter of the colour of soot, and as light as lampblack. The prusside of silver gives out likewise prussine when heated; but the mercurial prusside is preferable to every other.

Prussine or cyanogen is a permanently elastic fluid. Its smell, which it is impossible to describe, is very strong and penetrating. Its solution in water has a very sharp taste. The gas burns with a bluish flame mixed with purple. Its sp. gr., compared to that of air, is 1.8064. M. Gay-Lussac obtained it by weighing at the same temperature, and under the same pressure, a balloon of about 2½ litres, (152.56 cubic inches,) in which the vacuum was made to the same degree, and alternately full of air and prussine. 100 cubic inches weigh therefore 55.1295 grains.

Prussine is capable of sustaining a pretty high heat, without being decomposed. Water, with which M. Gay-Lussac agitated it, for some minutes, at the temperature of 68°, absorbed about 4½ times its volume. Pure alcohol absorbs 23 times its volume. Sulphuric ether and oil of turpentine dissolve at least as much as water. Tincture of litmus is reddened by prussine. On heating the solution the gas is disengaged, mixed with a little carbonic acid, and the blue colour of the litmus is restored. The carbonic acid proceeds no doubt from the decomposition of a small quantity of prussine and water. It deprives the red sulphate of manganese of its colour, a property which prussic acid does not possess. This is a proof that its elements have more mobility than those of the acid. In the dry way, it separates the carbonic acid from the carbonates.

Phosphorus, sulphur, and iodine may be sublimed by the heat of a spirit-lamp in prussine, without occasioning any change on it. Its mixture with hydrogen was not altered by the same temperature, or by passing electrical sparks through it. Copper and gold do not combine with it, but iron, when heated almost to whiteness, decomposes it in part. The metal is covered with a slight coating of charcoal, and becomes brittle. The undecomposed portion of the gas is mixed with azote, (contains free azote.) In one trial the azote constituted 0.44 of the mixture, but in general it was less. Platinum, which had been placed beside the iron, did not undergo any alteration. Neither its surface nor that of the tube was covered with charcoal like the iron.

In the cold, potassium acts but slowly on prussine, because a crust is formed on its surface, which presents an obstacle to the mutual action. On applying the spirit-lamp, the potassium becomes speedily incandescent; the absorption of the gas begins, the inflamed disc gradually diminishes, and when it disappears entirely, which takes place in a few seconds, the absorption is likewise at an end. Supposing we employ a quantity of potassium that would disengage 50 parts of hydrogen from water, we find that from 48 to 50 parts of gas have disappeared. On treating the residue with potash, there usually remains 4 or 5 parts of hydrogen, sometimes 10 or 12. M. Gay-Lussac made a great number of experiments to discover the origin of this gas. He thinks that it is derived from the water which the prusside of mercury contains, when it has not been sufficiently dried. Prussic acid vapour is then produced, which, when decomposed by the potassium, leaves half its volume of hydrogen. Potassium therefore absorbs a volume of pure prussine, equal to that of the hydrogen, which it would disengage from water.

The compound of prussine and potassium is yellowish. It dissolves in water without effervescence, and the solution is strongly alkaline. Its taste is the same as that of hydrocyanate or simple prussiate of potash, of which it possesses all the properties.

The gas being very inflammable, M. Gay-Lussac exploded it in Volta's eudiometer, with about 2½ times its volume of oxygen. The detonation is very strong; and the flame is bluish, like that of sulphur burning in oxygen.

Supposing that we operate on 100 parts of prussine, we find after the explosion a diminution of volume, which amounts to from four to nine parts. When the residuum is treated with potash or barytes, it diminishes from 195 to 200 parts, which are carbonic acid gas. The new residuum, analyzed over water by hydrogen, gives from 94 to 98 parts of azote, and the oxygen which it contains, added to that in the carbonic acid, is equal (within four or five per cent), to that which has been employed.

Neglecting the small differences, which prevent these numbers from having simple ratios to each other, and which, like the presence of hydrogen, depend upon the presence of a variable portion of prussic acid vapour in the prussine employed, proceeding from the water left in the prusside of mercury, we may admit that prussine contains a sufficient quantity of carbon to produce twice its volume of carbonic acid gas; that is to say, two volumes of the vapour of carbon, and one volume of azote, condensed into a single volume. If that supposition be exact, the density of the radical derived from it ought to be equal to the density derived from experiment; but supposing the density of air to be 1.00, twice that of the vapour of

Carbon is	0.8320	(0.8332)
Azote,	0.9691	(0.9722)
	1.8011	1.8054

From the near agreement of these numbers with the experimental density, we are entitled to conclude that M. Gay-Lussac's analysis is correct. By adding a volume of hydrogen to a volume of prussine, we obtain two volumes of prussic acid vapour; just as by adding a volume of hydrogen to a volume of chlorine, we obtain two volumes of muriatic acid gas. The same proportions hold with regard to the vapour of iodine, hydrogen, and hydriodic acid. Hence the sp. gr. of these three hydrogen-acids is exactly equal to half the sum of the densities of their respective bases and hydrogen. This fine analogy was first established by M. Gay-Lussac.

It is now obvious that the action of potassium on prussine agrees with its action on prussic acid. We have seen that it absorbs 50 parts of the first, and likewise that it absorbs 100 parts of the second, from which it separates 50 parts of hydrogen. But 100 parts of prussic acid vapour, *minus* 50 parts of hydrogen, amount exactly to 50 parts prussine. Hence the two results agree perfectly, and the two compounds obtained ought to be identical, which agrees precisely with experiment.

The analysis of prussine being of great importance, M. Gay-Lussac attempted it likewise by other methods. Having put prusside of mercury into the bottom of a glass tube, he covered it with brown oxide of copper, and then raised the heat to a dull red. On heating gradually the part of the tube containing the prusside, the prussine was gradually disengaged, and passed through the oxide, which it reduced completely to the metallic state. On washing the gaseous products with aqueous potash, at different parts of the process, he obtained only from 0.19 to 0.30 of azote, instead of 0.33, which ought to have remained according to the preceding analysis. Presuming that some nitrous compound had been formed, he repeated the experiment, covering the oxide with a column of copper filings, which he kept at the same temperature as the oxide. With this new arrangement, the results were very singular; for the smallest quantity of azote which he obtained during the whole course of the experiment was 32.7 for 100 of gas, and the greatest was 34.4. The mean of all the trials was,—

Azote,	33.6 or nearly	1
Carbonic acid,	66.4	2

A result which shows clearly that prussine contains two volumes of the vapour of carbon, and one volume of azote.

In another experiment, instead of passing the prussine through the oxide of copper, he made a mixture of one part of the prusside of mercury, and 10 parts of the red oxide, and after introducing it into a glass tube, close at one end, he covered it with copper filings, which he raised first to a red heat. On heating the mixture successively, the decomposition went on with the greatest facility. The proportions of the gaseous mixture were less regular than in the preceding experiment. Their mean was,—

Azote,	34.6 instead of	33.3
Carbonic acid,	65.4	66.6

In another experiment he obtained,—

Azote,	32.2
Carbonic acid,	67.8

Now the mean of these results gives,—

Azote,	33.4
Carbonic acid,	66.6

No sensible quantity of water seemed to be formed during these analyses. This shows farther, that what has been called a prussiate of mercury is really a prusside of that metal.

When a pure solution of potash is introduced into this gas, the absorption is rapid. If the alkali be not too concentrated, and be not quite saturated, it is scarcely tinged of a lemon-yellow colour. But if the prussine be in excess, we obtain a brown solution, apparently carbonaceous. On pouring potash combined with prussine into a saline solution of a black oxide of iron, and adding an acid, we obtain prussian blue. It would appear from this phenomenon that the prussine is decomposed the instant that it combines with the potash; but this conclusion is premature; for when this body is really decomposed by means of an alkaline solution, carbonic acid is always produced, together with prussic acid and ammonia. But on pouring barytes into a solution of prussine in potash, no precipitate takes place, which shows that no carbonic acid is present. On adding an excess of quicklime, no trace of ammonia is perceptible. Since, then, no carbonic acid and ammonia have been formed, water has not been decomposed, and consequently no prussic acid evolved. How then comes the solution of prussine in potash to produce prussian blue, with a solution of iron and acid? The following is M. Gay-Lussac's ingenious solution of this difficulty:—

The instant an acid is poured into he solution of prussine in potash, a strong effervescence of carbonic acid is produced, and at the same time a strong smell of prussic acid becomes perceptible. Ammonia is likewise formed, which remains combined with the acid employed, and which may be rendered very sensible to the smell by the addition of quicklime. Since therefore we are obliged to add an acid in order to form prussian blue, its formation occasions no farther difficulty.

Soda, barytes, and strontites produce the same effect as potash. We must therefore admit that prussine forms particular combinations with the alkalis, which are permanent till some circumstance determines the formation of new products. These combinations are true salts, which may be regarded as analogous to those formed by acids. In fact prussine possesses acid characters. It contains two elements, azote and carbon, the first of which is strongly acidifying, according to M. Gay-Lussac. (Is it not as strongly alkalifying, with hydrogen, in ammonia?) Prussine reddens the tincture of litmus, and neutralizes the bases. On the other hand, it acts as a simple body, when it combines with hydrogen; and it is this double function of a simple and compound body which renders its nomenclature so embarrassing.

Be this as it may, the compounds of prussine and the alkalis, which may be distinguished by the term *prussides*, do not separate in water, like the alkaline chlorurets, (oxymuriates,) which produce chlorates and muriates. But when an acid is added, there is formed, 1st, Carbonic acid, which corresponds to the chloric acid; 2d, Ammonia and prussic acid, which correspond to the muriatic.

When the prusside of potash is decomposed by an acid, there is produced a volume of carbonic acid just equal to that of the prussine employed. What then becomes of the other volume of the vapour of carbon; for the prussine contains two, with one volume of azote?

Since there is produced, at the expense of the oxygen of the water, a volume of carbonic acid, which represents 1 volume of oxygen, 2 volumes of hydrogen must likewise have been produced. Therefore, neglecting the carbonic acid, there remains

1 volume vapour of carbon,
1 azote,
2 hydrogen;

and we must make these three elements combine in totality, so as to produce only prussic acid and ammonia. But the one volume of the vapour of carbon, with half a volume of azote, and half a volume of hydrogen, produces exactly 1 volume of prussic acid, while the volume and a half of hydrogen, and the half volume of azote remaining, produce 1 volume of ammoniacal gas; for this substance is formed of 3 volumes of hydrogen and 1 of azote, condensed into 2 volumes. See Ammonia.

A given volume of prussine, then, combined first with an alkali, and then treated with an acid, produces exactly

1 volume of carbonic acid gas,
1 prussic acid vapour,
1 ammoniacal gas.

It is very remarkable to see an experiment, apparently very complicated, give so simple a result.

The metallic oxides do not seem capable of producing the same changes on prussine as the alkalis. Having precipitated protosulphate of iron by an alkali, so that no free alkali remained, M. Gay-Lussac caused the oxide of iron (mixed necessarily with much water) to absorb prussine, and then added muriatic acid. But he did not obtain the slightest trace of prussian blue; though the same oxide, to which he had added a little potash before adding the acid, produced it in abundance.§

From this result one is induced to believe that oxide of iron does not combine with prussine; and so much the more, because water impregnated with this gas never produces prussian blue with solutions of iron, unless we begin by adding an alkali. (See Prussic Acid.) The peroxides of manganese and mercury, and the deutoxide of lead, absorb prussine, but very slowly. If we add water, the combination is much more rapid. With the peroxide of mercury, we obtain a grayish-white compound, somewhat soluble in water.

Prussine rapidly decomposes the carbonates at a dull red heat, and prussides of the oxides are obtained. When passed through sulphuret of barytes, it combines without disengaging the sulphur, and renders it very fusible, and of a brownish-black colour. When put into water, we obtain a colourless solution, but which gives a deep brown (maroon) colour to muriate of iron. What does not dissolve contains a good deal of sulphate, which is doubtless formed during the preparation of the sulphuret of barytes.

On dissolving prussine in the sulphuretted hydrosulphuret of barytes, sulphur is precipitated, which is again dissolved when the liquid is saturated with prussine, and we obtain a solution having a very deep brown maroon colour. This gas does not decompose sulphuret of silver, or of potash.

Prussine and sulphuretted hydrogen combine slowly with each other. A yellow substance is obtained in fine needles, which dissolves in water, does not precipitate nitrate of lead, produces no prussian blue, and is composed of 1 volume prussine (cyanogen,) and 1½ volume of sulphuretted hydrogen.§

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§ Does not this experiment justify the adoption of the term *prussine;* since we see that very complicated affinities must be exercised before blue is produced by cyanogen?

Ammoniacal gas and prussine begin to act on each other whenever they come in contact; but some hours are requisite to render the effect complete. We perceive at first a white thick vapour, which soon disappears. The diminution of volume is considerable, and the glass in which the mixture is made, becomes opaque, its inside being covered with a solid brown matter. On mixing 90 parts of prussine, and 227 ammonia, they combined nearly in the proportion of 1 to 1½. This compound gives a dark orange-brown colour to water, but dissolves only in a very small proportion. The liquid produces no prussian blue with the salts of iron.

When prussic acid is exposed to the action of a voltaic battery of 20 pairs of plates, much hydrogen gas is disengaged at the negative pole, while nothing appears at the positive pole. It is because there is evolved at that pole, prussine, which remains dissolved in the acid. We may, in this manner, attempt the combination of metals with prussine, placing them at the positive pole.

It is easy now to determine what takes place, when an animal matter is calcined with potash or its carbonate. A prusside of potash is formed. It has been proved, that by heat, potash separates the hydrogen of the prussic or hydrocyanic acid. We cannot then suppose that this acid is formed, while a mixture of potash and animal matters is exposed to a high temperature. But we obtain a prusside of potash, and not of potassium; for this last, when dissolved in water, gives only prussiate of potash (hydrocyanate,) which is decomposed by the acids, without producing ammonia and carbonic acid; while the prusside of potash (cyanide) dissolves in water, without being altered, and does *not* give ammonia, carbonic acid, and prussic (hydrocyanic) acid vapour, unless an acid be added. This is the character, which distinguishes a prusside of a metal, from a prusside of a metallic oxide. See Acid (Prussic.)

The preceding facts are taken from M. Gay-Lussac's memoir on hydrocyanic acid, presented to the Institute, September 18, 1815, and published in the Annales de Chimie, vol. xcv.

In the Journal de Pharmacie for November 1818, M. Vauquelin has published an elaborate dissertation on the same subject, of which I have given some extracts under Acid (Prussic.) I shall insert here his very elegant process for obtaining pure hydrocyanic or prussic acid, from the cyanide or prusside of mercury.

Considering that mercury has a strong attraction for sulphur, and that prussine unites easily to hydrogen, when presented in the proper state, he thought that sulphuretted hydrogen might be employed for decomposing dry cyanide (prusside) of mercury. He operated in the following way:—He made a current of sulphuretted hydrogen gas, disengaged slowly from a mixture of sulphuret of iron, and very dilute sulphuric acid, pass slowly through a glass tube slightly heated, filled with the mercurial prusside, and communicating with a receiver, cooled by a mixture of salt and snow.

As soon as the sulphuretted hydrogen came in contact with the mercurial salt, this last substance blackened, and this effect gradually extended to the farthest extremity of the apparatus. During this time no trace of sulphuretted hydrogen could be perceived at the mouth of a tube proceeding from the receiver. As soon as the odour of this gas began to be perceived, the process was stopped; and the tube was heated in order to drive over the acid which might still remain in it. The apparatus being unluted, he found in the receiver a colourless fluid, which possessed all the known properties of prussic acid. It amounted to nearly the fifth part of the prusside of mercury employed.

This process is easier, and furnishes more acid, than M. Gay-Lussac's, by means of muriatic acid. He repeated it several times, and always successfully. It is necessary, merely to take care to stop the process, before the odour of the sulphuretted hydrogen begins to be perceived; otherwise, the hydrocyanic acid will be mixed with it. However, we may avoid this inconvenience, by placing a little carbonate of lead at the extremity of the tube. As absolute hydrocyanic acid is required only for chemical researches, and as it cannot be employed in medicine, it may be worth while, says M. Vauquelin, to bring to the recollection of apothecaries, a process of M. Proust, which has, perhaps, escaped their attention. It consists in passing a current of sulphuretted hydrogen gas through a cold saturated solution of prussiate of mercury in water, till the liquid contains an excess of it; to put the mixture into a bottle, in order to agitate it from time to time; and finally to filter it.

If this prussic acid, as almost always happens, contain traces of sulphuretted hydrogen, agitate it with a little carbonate of lead, and filter it again. By this process we may obtain hydrocyanic acid, in a much greater degree of concentration than is necessary for medicine. It has the advantage over the dry prussic acid, of being capable of being preserved a long time, always taking care to keep it as much as possible from the contact of air and heat. Dr. Nimmo's directions for preparing the prusside of mercury ought to be attended to. His experiments, it will be seen, coincide perfectly with the views so admirably developed by M. Gay-Lussac. See ACID (PRUSSIC.)

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§ This is the compound, which Dr. Thomson, from atomic considerations, declares to be destitute of hydrogen.

In the first volume of the Journal of Science and the Arts, Sir H. Davy has stated some interesting particulars relative to prussine. By heating prusside of mercury in muriatic acid gas, he obtained pure liquid prussic acid, and corrosive sublimate. By heating iodine, sulphur, and phosphorus, in contact with prusside of mercury, compounds of these bodies with prussine or cyanogen may be formed. That of iodine is a very curious body. It is volatile at a very moderate heat, and on cooling, collects in flocculi, adhering together like oxide of zinc formed by combustion. It has a pungent smell, and very acrid taste.*

* PULMONARY CONCRETIONS consist of carbonate of lime, united to a membranous or animal matter. By Mr. Crompton's analysis, *Phil. Mag.* vol. xiii. 100 parts contain,

carbonate of lime,	82
animal matter and water,	18

Disease proceeding from this cause, (and I believe it to be a frequent prelude and concomitant of ulcerated lungs,) might be probably benefited by the regular inhalation of aqueous vapour mixed with that of acetic acid or vinegar.*

* PUMICE. A mineral of which there are three kinds,—the glassy, common, and porphyritic.

1. *Glassy pumice.* Colour smoke-gray. Vesicular. Glistening, pearly. Fracture promiscuous fibrous. Translucent. Between hard and semi-hard. Very brittle. Feels rough, sharp, and meagre. Sp. gr. 0.378 to 1.44. It occurs in beds in the Lipari Islands.

2. *Common pumice.* Colour nearly white. Vesicular. Glimmering, pearly. Fracture fibrous. Translucent on the edges. Semi-hard. Very brittle. Meagre and rough. Sp. gr. 0.752 to 0.914. It melts into a gray coloured slag. Its constituents are, silica 77.5, alumina 17.5, natron and potash 3, iron mixed with manganese 1.75.—*Klaproth.* It occurs with the preceding.

3. *Porphyritic pumice.* Colour grayish-white. Massive. Minutely porous. Glimmering and pearly. Sp. gr. 1.661. It contains crystals of feldspar, quartz, and mica. It is associated with claystone, obsidian, pearlstone and pitchstone-porphyry. It occurs in Hungary, at Tokay, &c.*

* PUTREFACTION. The spontaneous decomposition of such animal or vegetable matters, as exhale a fetid smell, is called putrefaction. The solid and fluid matters are resolved into gaseous compounds and vapours which escape, and into an earthy residuum. See ADIPOCERE, and FERMENTATION, of which *genus,* putrefaction is merely a *species.* As the grand resolvent of organic matter is water, its abstraction by drying, or fixation by cold, by salt, sugar, spices, &c. will counteract the process of putrefaction. The atmospheric air is also active in putrefaction; hence, its exclusion favours the preservation of food; on which principle, some patents have been obtained.*

* PYRENEITE. Colour grayish-black. Massive, and crystallized in rhomboidal dodecahedrons. Glistening, and metal-like. Fracture uneven. Opaque. Hard. Sp. gr. 2.5? It melts with intumescence, into a yellowish-green vesicular enamel. Its constituents are, silica 43, alumina 16, lime 20, oxide of iron 16, water 4.—*Vauquelin.* It occurs in primitive limestone, in the Pic of Eres-Lids, near Bareges, in the French Pyrenees.*

* PYRITES. Native compounds of metal with sulphur. See the particular metallic ORES.*

* PYROGOM. A variety of diopside.*

* PYROMETER. The most celebrated instrument for measuring high temperatures, is that invented by the late Mr. Wedgwood, founded on the principle, that clay progressively contracts in its dimensions, as it is progressively exposed to higher degrees of heat. He formed his white porcelain clay, into small cylindrical pieces, in a mould, which, when they were baked in a dull red heat, just fitted into the opening of two brass bars, fixed to a brass plate, so as to form a tapering space between them. This space is graduated; and the farther the pyrometric clay gauge can enter, the greater heat does it indicate. The two converging rules are placed at a distance of 0.5 of an inch at the commencement of the scale, and of 0.3 at the end.

Mr. Wedgwood sought to establish a correspondence between the indications of his pyrometer, and those of the mercurial thermometer, by employing a heated rod of silver, whose expansions he measured, as their connecting link. The clay-piece and silver rod were heated in a muffle.*

When the muffle appeared of a low red heat, such as was judged to come fully within the province of his thermometer, it was drawn forward toward the door of the oven, and its own door being then nimbly opened by an assistant, Mr. Wedgwood pushed the silver piece as far as it would go. But as the division, which it went to, could not be distinguished in that ignited state, the muffle was lifted out, by means of an iron rod passed through two rings made for that purpose, with care to keep it steady, and avoid any shake that might endanger the displacing of the silver piece.

When the muffle was grown sufficiently cold to be examined, he noted the degree of expansion which the silver piece stood at, and the degree of heat shown by the thermometer pieces measured in their own gauge; then returned the whole into the oven as before, and repeated the operation with a stronger heat, to obtain another point of correspondence on the two scales.

The first was at 2¼° of his thermometer, which coincided with 66° of the intermediate one; and as each of these last had been before found to contain 20° of Fahrenheit's, the 66 will contain 1320; to which add 50, the degree of his scale to which the (0) of the intermediate thermometer was adjusted, and the sum 1370 will be the degree of Fahrenheit's corresponding to his 2¼°.

The second point of coincidence was at 6¼° of his, and 92° of the intermediate; which 92 being, according to the above proportion, equivalent to 1840 of Fahrenheit, add 50 as before to this number, and his 6¼° is found to fall upon the 1890th degree of Fahrenheit.

It appears hence that an interval of four degrees upon Mr. Wedgwood's thermometer is equivalent to an interval of 520° upon that of Fahrenheit; and, consequently, one of the former to 130° of the latter; and that the (0) of Mr. Wedgwood corresponds to 1077½° of Fahrenheit.

From these data it is easy to reduce either scale to the other through their whole range; and from such reduction it will appear, that an interval of near 480° remains between them, which the intermediate thermometer serves as a measure for; that Mr. Wedgwood's includes an extent of about 32000 of Fahrenheit's degrees, or about 54 times as much as that between the freezing and boiling points of mercury, by which mercurial ones are naturally limited; that if the scale of Mr. Wedgwood's thermometer be produced downward, in the same manner as Fahrenheit's has been supposed to be produced upward, for an ideal standard; the freezing point of water would fall nearly on 8° below (0) of Mr. Wedgwood's, and the freezing point of mercury a little below 8½°; and that, therefore, of the extent of now measurable heat, there are about 5-10ths of a degree of his scale from the freezing of mercury to the freezing of water; 8° from the freezing of water to full ignition; and 160° above this to the highest degree he has hitherto attained.

Mr. Wedgwood concludes his account with the following table of the effects of heat on different substances, according to Fahrenheit's thermometer, and his own.

	Fahr.	*Wedg.*
Extremity of the scale of his thermometer	32277°	240°
Greatest heat of his small air furnace	21877	160
Cast iron melts	17977	130
Greatest heat of a common smith's forge	17327	125
Welding heat of iron, greatest	13427	95
Welding heat of iron, least	12777	90
Fine gold melts	5237	32
Fine silver melts	4717	28
Swedish copper melts	4587	27
Brass melts	3807	21
Heat by which his enamel colours are burnt on	1857	6
Red heat fully visible in day-light	1077	0
Red heat fully visible in the dark	947	— 1
Mercury boils	600	$3\frac{673}{1000}$
Water boils	212	$6\frac{658}{1000}$
Vital heat	97	$7\frac{542}{1000}$
Water freezes	32	$8\frac{42}{1000}$
Proof spirit freezes	0	$8\frac{289}{1000}$
The point at which mercury congeals, consequently the limit of mercurial thermometers, about	— 40	$8\frac{596}{1000}$

In a scale of HEAT drawn up in this manner, the comparative extents of the different departments of this grand and universal agent are rendered conspicuous at a single glance of the eye. We see at once, for instance, how small a portion of it is concerned in animal and vegetable life, and in the ordinary operations of nature. From freezing to vital heat is barely a five-hundredth part of the scale; a quantity so inconsiderable, relatively to the whole, that in the higher stages of ignition, ten times as much might be added or taken away, without the least difference being discernible in any of the appearances from which the intensity of fire has hitherto been judged of. Hence, at the same time, we may be convinced of the utility and importance of a physical measure for these higher degrees of heat, and the utter insufficiency of the common means of discriminating and estimating their force. Mr. Wedgwood adds, that he has often found differences, astonishing when considered as a part of this scale, in the heats of his own kilns and ovens, without being perceivable by the workmen at the time, or till the ware was taken out of the kiln.

* Since dry air augments in volume, 3-8ths for 180 degrees, and, since its progressive rate of expansion is probably uniform by uniform increments of heat, a pyrometer might easily be constructed on this principle. Form a bulb and tube of platinum, of exactly the same form as a thermometer, and connect with the extremity of the stem, at right angles, a glass tube of uniform calibre, filled with mercury, and terminating below in a recurved bulb, like that of the Italian barometer.

Graduate the glass tube into a series of spaces equivalent to 3-8ths of the total volume of the capacity of the platina bulb, with 3-4ths of its stem. The other fourth may be supposed to be little influenced by the source of heat. On plunging the bulb and 2-3ds of the stem into a furnace, the depression of the mercury will indicate the degree of heat. As the movement of the column will be very considerable, it will be scarcely worth while to introduce any correction for the change of the initial volume by barometric variation. Or the instrument might be made, with the recurved bulb sealed, as in Professor Leslie's differential thermometers. The glass tube may be joined by fusion to the platinum tube. Care must be taken to let no mercury enter the platinum bulb. Should there be a mechanical difficulty in making a bulb of this metal, then a hollow cylinder of ½ inch diameter, with a platinum stem, like that of a tobacco-pipe, screwed into it, will suit equally well.*

Pyrophorus. By this name is denoted an artificial product, which takes fire or becomes ignited on exposure to the air. Hence, in the German language, it has obtained the name of luft-zunder, or air-tinder. It is prepared from alum by calcination, with the addition of various inflammable substances. Homberg was the first that obtained it, which he did accidentally in the year 1680, from a mixture of human excrement and alum, upon which he was operating by fire.

The preparation is managed in the following manner. Three parts of alum are mixed with from two to three parts of honey, flour, or sugar; and this mixture is dried over the fire in a glazed bowl, or an iron pan, diligently stirring it all the while with an iron spatula. At first this mixture melts, but by degrees it becomes thicker, swells up, and at last runs into small dry lumps. These are triturated to powder, and once more roasted over the fire, till there is not the least moisture remaining in them, and the operator is well assured that it can liquefy no more: the mass now looks like a blackish powder of charcoal. For the sake of avoiding the previous above-mentioned operation, from four to five parts of burned alum may be mixed directly with two of charcoal powder. This powder is poured into a phial or matrass, with a neck about six inches long. The phial, which however must be filled three-quarters full only, is then put into a crucible, the bottom of which is covered with sand and so much sand is put round the former, that the upper part of its body also is covered with it to the height of an inch; upon this, the crucible, with the phial, is put into the furnace, and surrounded with red-hot coals. The fire, being now gradually increased till the phial becomes red-hot, is kept up for the space of about a quarter of an hour, or till a black smoke ceases to issue from the mouth of the phial, and instead of this a sulphureous vapour exhales, which commonly takes fire. The fire is kept up till the blue sulphureous flame is no longer to be seen; upon this the calcination must be put an end to, and the phial closed for a short time with a stopper of clay or loam. But as soon as the vessel is become so cool as to be capable of being held in the hand, the phial is taken out of the sand, and the powder contained in it transferred as fast as possible from the phial, into a dry and stout glass made warm, which must be secured with a glass stopper.

We have made a very good pyrophorus by simply mixing three parts of alum with one of wheat-flour, calcining them in a common phial till the blue flame disappeared; and have kept it in the same phial, well stopped with a good cork when cold.

If this powder be exposed to the atmosphere, the sulphuret attracts moisture from the air, and generates sufficient heat to kindle the carbonaceous matter mingled with it.

* **Pyrope.** A sub-species of dodecahedral garnet. Colour dark blood-red, appearing yellowish by transmitted light. In grains. Splendent. Fracture conchoidal. Transparent. Refracts double. Scratches quartz more readily than precious garnet. Sp. gr. 3.718. Its constituents are, silica 40, alumina 28.5, magnesia 10, lime 3.5, oxide of iron 16.5, of manganese, 0.25, oxide of chrome 2, loss 1.25.—*Klaproth.* It occurs in trap-tuff, at Ely, in Fifeshire; and in claystone in Cumberland. At Zœblitz, Saxony, it is imbedded in serpentine. It is highly valued as a gem in jewellery.*

* **Pyrophysalite.** See **Physalite.***

* **Pyrosmalite.** Colour liver-brown, inclining to pistachio-green. In lamellar concretions, and in regular six-sided prisms, or the same truncated. Shining. Fracture uneven. Translucent. Semi-hard. Streak brownish-white. Brittle. Sp. gr. 3.08. It is insoluble in water, but soluble in muriatic acid with a small residuum of silica. It gives out vapours of chlorine before the blow-pipe, and becomes a magnetic oxide of iron. Its constituents are, peroxide of iron 21.81, protoxide of manganese 21.14, submuriate of iron 14.09, silica 35.85, lime 1.21, water and loss 5.9.—*Hisinger.* It occurs in a bed of magnetic ironstone, along with calcareous spar and hornblende, in Bjelke's mine in Nordmark, near Philipstadt in Wermeland. It is a very singular compound.*

* **Pyrotartaric Acid.** See **Acid (Pyrotartaric).***

* **Pyroxene.** Augite.*

Q

QUARTATION is an operation by which the quantity of one thing is made equal to a fourth part of the quantity of another thing. Thus, when gold alloyed with silver is to be parted, we are obliged to facilitate the action of the aquafortis by reducing the quantity of the former of these metals to one-fourth part of the whole mass; which is done by sufficiently increasing the quantity of the silver, if it be necessary. This operation is called quartation, and is preparatory to the parting; and even many authors extend this name to the operation of parting. See ASSAY.

* **QUARTZ.** Professor Jameson divides this mineral genus into two species; rhomboidal quartz, and indivisible quartz.

1. *Rhomboidal quartz* contains 14 sub-species. 1. Amethyst. 2. Rock crystal. 3. Milk quartz. 4. Common quartz. 5. Prase. 6. Cat's Eye. 7. Fibrous quartz. 8. Iron flint. 9. Hornstone. 10. Flinty slate. 11. Flint. 12. Calcedony. 13. Heliotrope. 14. Jasper.

2. *Indivisible quartz* contains nine sub-species: 1. Float-stone. 2. Quartz sinter. 3. Hyalite. 4. Opal. 5. Menilite. 6. Obsidian. 7. Pitchstone. 8. Pearlstone. 9. Pumice-stone. We shall treat here of the quartz sub-species.

1. *Rose*, or *Milk quartz*. Colour rose-red, and milk-white. Massive. Shining. Fracture conchoidal. Translucent. It is probably silica, coloured with manganese. It is found in Bavaria, where it occurs in beds of quartz in granite, near Zwiesel, &c.

2. *Common quartz*. Colours, white, gray, and many others. Massive, disseminated, imitative, in impressed forms, in supposititious and true crystals. The latter are, a six-sided prism, acuminated on both extremities by six planes; a simple six-sided pyramid, and a double six-sided pyramid. Splendent to glistening. Fracture coarse splintery, and sometimes slaty. Translucent. It is one of the most abundant minerals in nature.

3. *Fibrous quartz*. Colours greenish and yellowish-white. Massive, and in rolled pieces. In curved fibrous concretions. Glimmering and pearly. Fracture curved slaty. Translucent on the edges. Nearly as hard as quartz. Not very difficultly frangible. Sp. gr. 3.123? It occurs on the banks of the Moldare in Bohemia.

4. *Quartz*, or *siliceous sinter*. Of this there are three kinds; the common, opaline, and pearly.

§ 1. *Common*. Colours grayish-white and reddish-white. Massive and imitative. Dull. Fracture flat conchoidal. Translucent on the edges. Semi-hard. Very brittle. Sp. gr. 1.81. Its constituents are, silica 98, alumina 1.5, iron 0.5.—*Klapr.* It occurs abundantly round the hot springs in Iceland.

§ 2. *Opaline siliceous sinter*. Colour yellowish-white. Massive. Fracture conchoidal. Glimmering. Translucent on the edges. Semi-hard. Brittle. Adheres to the tongue. It occurs at the hot springs in Iceland. It resembles opal.

§ 3. *Pearl sinter*, or *fiorite*. Colour milk-white. In imitative shapes. Lustre between resinous and pearly. In thin concentric lamellar concretions. Fracture fine grained uneven. Translucent. Scratches glass, but not so hard as quartz. Brittle. Sp. gr. 1.917. Its constituents are, silica 94, alumina 2, lime 4.—*Santi.* It has been found in volcanic tuff and pumice, in the Vicentine. See ROCK CRYSTAL.*

* **QUERCITRON.** See DYEING.*

* **QUICKSILVER.** See MERCURY.*

R

RADICAL. That which is considered as constituting the distinguishing part of an acid, by its union with the acidifying principle, or oxygen, which is common to all acids. Thus, sulphur is the radical of the sulphuric and sulphurous acids. It is sometimes called the base of the acid, but base is a term of more extensive application.

RADICAL VINEGAR. See ACID (ACETIC).

* **RAIN.** Mr. Luke Howard, who may be considered as our most accurate scientific meteorologist, is inclined to think, that rain is in almost every instance the result of the *electrical* action of clouds upon each other. This idea is confirmed by observations made in various ways, upon the electrical state of clouds and rain; and it is very probable that a thunder-storm is only a more sudden and sensible display of those energies, which, according to the order observable in the creation in other respects, ought to be incessantly and silently operating for more general and beneficial purposes.

In the formation of the rain-cloud (*nimbus*), two circumstances claim particular attention; the spreading of the superior masses of cloud, in all directions, until they become like the *stratus*, one uniform sheet; and the rapid motion, and visible decrease, of the *cumulus* when brought under the latter. The *cirri* also, which so frequently stretch from the superior sheet upwards, and resemble erected hairs, carry much the appearance of temporary conductors for the electricity, extricated by the sudden union of minute particles of vapour, into the vastly larger ones that form the rain. By one experiment of Cavallo's, with a kite carrying 360 feet of conducting string, in an interval between two showers, and kept up during rain, it seems that the superior clouds possessed a positive electricity before the rain, which on the arrival of a large *cumulus*, gave place to a very strong negative, continuing as long as it was over the kite. We are not, however, warranted from this to conclude the *cumulus* which brings on rain always negative, as the same effect might ensue from a positive *cumulus* uniting with a negative *stratus*. Yet the general negative state of the lower atmosphere during rain, and the positive indications commonly given by the true *stratus*, render this the more probable opinion. It is not, however, absolutely necessary to determine the several states of the clouds which appear during rain, since there is sufficient evidence in favour of the conclusion, that clouds formed in different parts of the atmosphere, operate on each other, when brought near enough, so as to occasion their partial or entire destruction; an effect which can be attributed only to their possessing beforehand, or acquiring at the moment, the opposite electricities.

It may be objected, says Mr. Howard, that this explanation is better suited to the case of a shower, than to that of continued rain, for which it does not seem sufficient. If it should appear, nevertheless, that the supply of each kind of cloud is by any means kept up in proportion to the consumption, the objection will be answered. Now, it is a well known fact, that evaporation from the surface of the earth and waters, often returns and continues during rain, and consequently furnishes the lower clouds while the upper are recruited from the quantity of vapour brought by the superior current, and continually subsiding in the form of dew, as is evident both from the turbidness of the atmosphere in rainy seasons, and the plentiful deposition of dew in the nocturnal intervals of rain. Neither is it pretended that electricity is any further concerned in the production of rain, than as a secondary agent, which modifies the effect of the two grand predisposing causes,—a falling temperature, and the influx of vapour.

Mr. Dalton, who has paid much attention to meteorology, has recently read before the Manchester Society, an elaborate and interesting memoir on rain, from which I shall extract a table, and some observations.

Mean Monthly and Annual Quantities of Rain at various Places, being the Averages for many years, by Mr. Dalton.

	Manchester, 33 *years*.	*Liverpool*, 18 *years*.	*Chatsworth*, 16 *years*.	*Lancaster*, 20 *years*.	*Kendal*, 25 *years*.	*Dumfries*, 16 *years*.	*Glasgow*, 17 *years*.	*London*, 40 *years*.	*Paris*, 15 *years*.	*Viviers*, 40 *years*.	*General average*.
	Inch.	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Fr. In.*	*Fr. In.*	*Inch.*
Jan.	2.310	2.177	2.196	3.461	5.299	3.095	1.595	1.464	1.228	2.477	2.530
Feb.	2.568	1.847	1.652	2.995	5.126	2.837	1.741	1.250	1.232	1.700	2.295
Mar.	2.098	1.523	1.322	1.753	3.151	2.164	1.184	1.172	1.190	1.927	1.748
April.	2.010	2.104	2.078	2.180	2.986	2.017	0.979	1.279	1.185	2.686	1.950
May.	2.895	2.573	2.118	2.460	3.480	2.568	1.641	1.636	1.767	2.931	2.407
June.	2.502	2.816	2.286	2.512	2.722	2.974	1.343	1.738	1.697	2.562	2.315
July.	3.697	3.663	3.006	4.140	4.959	3.256	2.303	2.448	1.800	1.882	3.115
Aug.	3.665	3.311	2.435	4.581	5.039	3.199	2.746	1.807	1.900	2.347	3.103
Sept.	3.281	3.654	2.289	3.751	4.874	4.350	1.617	1.842	1.550	4.140	3.135
Oct.	3.922	3.724	3.079	4.151	5.439	4.143	2.297	2.092	1.780	4.741	3.537
Nov.	3.360	3.441	2.634	3.775	4.785	3.174	1.904	2.222	1.720	4.187	3.120
Dec.	3.832	3.288	2.569	3.955	6.084	3.142	1.981	1.736	1.600	2.397	3.058
	36.140	34.118	27.664	39.714	53.944	36.919	21.331	20.686	18.649	33.977	

"*Observations on the Theory of Rain.*

"Every one must have noticed an obvious connexion between heat and the vapour in the atmosphere. Heat promotes evaporation, and contributes to retain the vapour when in the atmosphere, and cold precipitates or condenses the vapour. But these facts do not explain the phenomenon of rain, which is as frequently attended with an increase as with a diminution of the temperature of the atmosphere.

"The late Dr. Hutton, of Edinburgh, was, I conceive, the first person who published a correct notion of the cause of rain. (See Edin. Trans. vol. i. and ii. and Hutton's Dissertations, &c.) Without deciding whether vapour be simply expanded by heat, and diffused through the atmosphere, or chemically combined with it, he maintained from the phenomena that the quantity of vapour capable of entering into the air increases in a greater ratio than the temperature; and hence he fairly infers, that whenever two volumes of air of different temperatures are mixed together, each being previously saturated with vapour, a precipitation of a portion of vapour must ensue, in consequence of the *mean* temperature not being able to support the *mean* quantity of vapour.

"The cause of rain, therefore, is now, I consider, no longer an object of doubt. If two masses of air of unequal temperatures, by the ordinary currents of the winds, are intermixed, when saturated with vapour, a precipitation ensues. If the masses are under saturation, then less precipitation takes place, or none at all, according to the degree. Also the warmer the air, the greater is the quantity of vapour precipitated in like circumstances. Hence the reason why rains are heavier in summer than winter, and in warm countries than in cold.

"We now inquire into the cause why less rain falls in the first six months of the year than in the last six months. The whole quantity of water in the atmosphere in January is usually about three inches, as appears from the dew point, which is then about 32°. Now the force of vapour at that temperature is 0.2 of an inch of mercury, which is equal to 2.8 or three inches of water. The dew point in July is usually about 58° or 59°, corresponding to 0.5 of an inch of mercury, which is equal to seven inches of water; the difference is four inches of water, which the atmosphere then contains more than in the former month. Hence, supposing the usual intermixture of currents of air in both the intervening periods to be the same, the rain ought to be four inches less in the former period of the year than the average, and four inches more in the latter period, making a difference of eight inches between the two periods, which nearly accords with the preceding observations."*

Rancidity. The change which oils undergo by exposure to the air.

The rancidity of oils is probably an effect analogous to the oxidation of metals. It essentially depends on the combination of oxygen with the extractive principle, which is naturally united with the oily principle. This inference is proved by attending to the processes used to counteract or prevent the rancidity of oils.

Reagent. In the experiments of chemical analysis, the component parts of bodies may either be ascertained in quantity as well as quality, by the perfect operations of the laboratory, or their quality alone may be detected by the operations of certain bodies called reagents. Thus the infusion of galls is a reagent, which detects iron by a dark purple precipitate; the prussiate of potash exhibits a blue with the same metal, &c. See Analysis, and Waters (Mineral).

* **Realgar.** Sulphuret of arsenic, a native ore.*

Receiver. Receivers are chemical vessels, which are adapted to the necks or beaks of retorts, alembics, and other distillatory vessels, to collect, receive, and contain the products of distillations.

* **Red Chalk.** A kind of clay ironstone.*

* **Reddle.** Red chalk.*

Reduction, or Revivification. This word, in its most extensive sense, is applicable to all operations by which any substance is restored to its natural state, or which is considered as such: but custom confines it to operations by which metals are restored to their metallic state, after they have been deprived of this, either by combustion, as the metallic oxides, or by the union of some heterogeneous matters which disguise them, as fulminating gold, luna cornea, cinnabar, and other compounds of the same kind. These reductions are also called revivifications.

Refrigeratory. See Laboratory.

Regulus. The name regulus was given by chemists to metallic matters when separated from other substances by fusion. This name was introduced by alchemists, who, expecting always to find gold in the metal collected at the bottom of their crucibles after fusion, called this metal, thus collected, regulus, as containing gold, the king of metals. It was afterwards applied to the metal extracted from the ores of the semi-metals, which formerly bore the name that is now given to the semi-metals themselves. Thus we had regulus of antimony, regulus of arsenic, and regulus of cobalt.

Resin. The name *resin* is used to denote solid inflammable substances, of vegetable origin, soluble in alcohol, usually affording much soot by their combustion. They are likewise soluble in oils, but not at all in water; and are more or less acted upon by the alkalis.

All the resins appear to be nothing else but volatile oils, rendered concrete by their combination with oxygen. The exposure of these to the open air, and the decomposition of acids applied to them, evidently prove this conclusion.

There are some among the known resins which are very pure, and perfectly soluble in alcohol, such as the balsam of Mecca and of Capivi, turpentines, tacamahaca, elemi: others are less pure, and contain a small portion of extract, which renders them not totally soluble in alcohol; such are mastic, sandarach, guaiacum, labdanum, and dragon's blood.

What is most generally known by the name of resin, simply, or sometimes of yellow resin, is the residuum left after distilling the essential oil from turpentine. If this be urged by a stronger fire, a thick balsam, of a dark reddish colour, called balsam of turpentine, comes over; and the residuum, which is rendered blackish, is called black resin, or colophony.

* Resin, analyzed by MM. Gay-Lussac and Thenard, was found to consist of

Carbon, 75.944
Hydrogen, 10.719 } water 15.156
Oxygen, 13.337 } hydr. in excess 8.9.*

* RESPIRATION. A function of animals, which consists in the alternate inhalation of a portion of air into an organ called the lungs, and its subsequent exhalation. The venous blood, which enters the lungs from the pulmonary artery, is charged with carbon, to which it owes its dark purple colour. When the atmospherical oxygen is applied to the interior of the air vesicles of the lungs, it combines with the carbon of the blood, forms carbonic acid, which to the amount of from 4.5 to 8 per cent of the bulk of air inspired, is immediately exhaled. It does not appear that any oxygen or azote is absorbed by the lungs in respiration; for the volume of carbonic acid generated is exactly equal to that of the oxygen which disappears. Now, we know that carbonic acid contains its own volume of oxygen. It is probable that the quantity of carbonic acid, produced in the lungs, varies in different individuals, and in the same individual under different circumstances. The change of the blood, from the purple venous to the bright red arterial, seems owing to the discharge of the carbon. An ordinary sized man consumes about 46 thousand cubic inches of oxygen *per diem;* equivalent to 125 cubic feet of air. He makes about 20 respirations in a minute; or breathes twice, for every seven pulsations. Dr. Prout and Dr. Fyfe found, that after swallowing intoxicating liquors, the quantity of carbonic acid formed in respiration was diminished. The same thing happens under a course of mercury, nitric acid, or vegetable diet.*

* RETINITE. Retin-asphalt.—*Hatchett.* Colour yellowish and reddish-brown. Massive, in angular pieces and thick crusts. Surface rough. Glistening, resinous. Fracture uneven. Translucent. Soft. Brittle. At first elastic, but becomes rigid by exposure to the air. Sp. gr. 1.135. On a hot iron, it melts, smokes and burns, with a fragrant odour. Soluble in potash, and partially in spirit of wine. Its constituents are, resin 55, asphalt 42, earth 3. It is found at Bovey Tracey in Devonshire, adhering to brown coal.*

RETORT. Retorts are vessels employed for many distillations, and most frequently for those which require a degree of heat superior to that of boiling water. This vessel is a kind of bottle with a long neck, so bent, that it makes with the belly of the retort an angle of about sixty degrees. From this form they have probably been named retorts. The most capacious part of the retort is called its belly. Its upper part is called the arch or roof of the retort, and the bent part is the neck.

* REUSITE. Colour white. As a mealy efflorescence, and crystallized, in flat six-sided prisms and acicular crystals. Shining. Fracture conchoidal. Soft. Its constituents are, sulphate of soda 66.04, sulphate of magnesia 31.35, muriate of magnesia 2.19, and sulphate of lime 0.42.—*Reuss.* It is found as an efflorescence on the surface, in the country round Sedlitz and Saidschutz.*

REVERBERATORY. See LABORATORY.

RHODIUM. A new metal discovered among the grains of crude platina by Dr. Wollaston. The mode of obtaining it in the state of a triple salt combined with muriatic acid and soda, has been given under the article *Palladium.* This may be dissolved in water, and the oxide precipitated from it in a black powder by zinc.

The oxide exposed to heat continues black; but with borax it acquires a white metallic lustre, though it remains infusible. Sulphur, or arsenic, however, renders it fusible, and may afterward be expelled by continuing the heat. The button however is not malleable. Its specific gravity appears to exceed 11.

Rhodium unites easily with every metal that has been tried, except mercury. With gold or silver it forms a very malleable alloy, not oxidated by a high degree of heat, but becoming incrusted with a black oxide when slowly cooled. One-sixth of it does not perceptibly alter the colour of gold, but renders it much less fusible. Neither nitric nor nitro-muriatic acid acts on it in either of these alloys; but if it be fused with three parts of bismuth, lead, or copper, the alloy is entirely soluble in a mixture of nitric acid with two parts of muriatic.

The oxide was soluble in every acid Dr. Wollaston tried. The solution in muriatic acid did not crystallize by evaporation. Its residuum formed a rose-coloured solution with alcohol. Muriate of ammonia and of soda, and nitrate of potash, occasioned no precipitate in the muriatic solution, but formed with the oxide, triple salts, which were insoluble in alcohol. Its solution in nitric acid likewise did not crystallize, but silver, copper, and other metals precipitated it.

The solution of the triple salt with muriate of soda was not precipitated by muriate, carbonate, or hydrosulphuret of ammonia, by carbonate or ferroprussiate of potash, or by carbonate of soda. The caustic alkalis however throw down a yellow oxide, soluble in excess of alkali; and a solution of platina occasions in it a yellow precipitate.

The title of this product to be considered as a distinct metal has been questioned; but the experiments of Dr. Wollaston have since been confirmed by Descotils.—*Philos. Trans.*

* **Rhoetizite.** Colour white. Massive, and in radiated concretions. Glistening and pearly. Fragments splintery. Feebly translucent on the edges. In other characters, the same as cyanite. It occurs in primitive rocks, with quartz, &c. at Pfitzsci in the Tyrol.*

* **Rhomb Spar.** Colour grayish-white. Massive, disseminated, and crystallized in rhomboids, in which the obtuse angle is 106° 15′. Splendent, between vitreous and pearly. Cleavage threefold oblique angular. Fracture imperfect conchoidal. Harder than calcareous spar; sometimes as hard as fluor. Brittle. Sp. gr. 2.8 to 3.2. It effervesces feebly with acids. Its constituents are, carbonate of lime 56.6, carbonate of magnesia 42, with a trace of iron and manganese.—*Murray.* It occurs imbedded in chlorite slate, limestone, &c. It is found on the banks of Loch Lomond; near Newton-Stewart in Galloway; in compact dolomite in the Isle of Man and the North of England. It has been called bitter spar and muricalcite.*

Rochelle Salt. Tartrate of potash and soda. See Acid (Tartaric).

* **Rock Butter.** Colour yellowish-white. Massive and tuberose. Glimmering. Fracture straight foliated. Translucent on the edges. Feels rather greasy. Easily Frangible. It is alum mixed with alumina and oxide of iron. It oozes out of rocks that contain alum. It occurs at the Hurlett alum-work, near Paisley.*

* **Rock Cork.** See Asbestus.*

* **Rock Crystal.** Colour white and brown. In rolled pieces, and crystallized. The primitive form is a rhomboid of 94° 15′ and 85° 45′. The secondary forms are, an equiangular six-sided prism, rather acutely acuminated on both extremities by six planes, which are set on the lateral planes; a double six-sided pyramid; an acute simple six-sided pyramid; an acute double three-sided pyramid. Splendent. Fracture perfect conchoidal. Transparent or translucent. Refracts double, feebly. Scratches feldspar. Rather easily frangible. Sp. gr. 2.6 to 2.88. When two pieces are rubbed against each other, they become phosphorescent, and exhale an electric odour. Its constituents are, silica 99 3-8ths, and a trace of ferruginous alumina. —*Bucholz.* Some chemists maintain, that it has one or two *per cent* of moisture. Crystals of great size and beauty are found in Arran, in drusy cavities in granite; but the finest are found in the neighbourhood of Cairngorm in Aberdeenshire, where they occur in granite, or in alluvial soil, along with beryl and topaz; and in the secondary greenstone of Burntisland in Fifeshire. The most magnificent groups of crystals come from Dauphiny.

The varieties inclosing crystals of titanium, the *Venus* hair-stones of amateurs, and those containing actynolite, or the *Thetis* hair-stones, are in much repute, and sell at a considerable price.—*Jameson.**

* **Rock Salt.** Hexahedral rock salt.

1. *Foliated.* Colours white and gray. Massive, disseminated, and crystallized in cubes. Splendent and resinous. Cleavage threefold rectangular. Fracture conchoidal. Fragments cubic. Translucent. As hard as gypsum. Feels rather greasy. Brittle. It has a saline taste. Sp. gr. 2.1 to 2.2.

2. *Fibrous.* Colour white. Massive, and in fibrous concretions. Glistening, resinous. Fragments splintery. Translucent. It decrepitates when heated. The constituents of Cheshire rock salt, in 1000 parts, are, muriate of soda 983¼, sulphate of lime 6½, muriate of magnesia 0.$\frac{5}{16}$, muriate of lime 0.$\frac{1}{16}$, insoluble matter 10.—*Henry.*

The greatest formation of rock salt is in the muriatiferous clay. The salt is occasionally associated with thin layers of anhydrite, stinkstone, limestone, and sandstone. The principal deposite in Great Britain is in Cheshire. The beds alternate with clay and marl, which contains gypsum. It occurs also at Droitwich, in Worcestershire. For other localities, see Professor Jameson's Mineralogy, iii. 6.*

* **Rock Wood.** See Asbestus.*

* **Roestone.** See Limestone.*

* **Rose Quartz.** See Quartz.*

* **Rubellite.** Red tourmalin.*

* **Ruby.** See Sapphire.*

* **Ruby-spinel.** See Spinel.*

* **Rust.** Red oxide of iron.*

* **Rutile.** An ore of titanium.*

S

* Saclactates. See Acid (Saclactic).*

* Safflower. See Carthamus.*

* Sagenite. Acicular Rutile.*

* Sahlite. Colours greenish-gray, and green of other shades. Massive, in straight lamellar concretions, and crystallized; in a broad rectangular four-sided prism, approaching the tabular form, or truncated on the lateral edges. Splendent on the principal fracture; on the cross fracture, dull. Cleavage fivefold. Fracture, uneven. Translucent on the edges. Harder than augite. Rather brittle. Sp. gr. 3.22 to 3.47. It melts with great difficulty. Its constituents are, silica 53, magnesia 19, alumina 3, lime 20, iron and manganese 4. —*Vauquelin.* It occurs in the Island of Unst in Shetland; in granular limestone in the Island of Tiree; and in Glentilt. It is a sub-species of oblique edged augite.*

Sal Alembroth. A compound muriate of mercury and ammonia. See Alembroth.

* Sal Ammoniac (Native); of which there are two kinds, the *volcanic* and *conchoidal.*

1. *Volcanic.* Colour yellowish and grayish-white. In efflorescences, imitative shapes, and crystallized; in an octohedron; rectangular four-sided prism, acuminated with four planes, set on the lateral planes; a cube truncated on the edges; a rhomboidal dodecahedron, and a double eight-sided pyramid, acuminated with four planes. Shining. Cleavage in the direction of the planes of the octohedron. From transparent to opaque. Harder than talc. Ductile and elastic. Sp. gr. 1.5 to 1.6. Taste sharp and urinous. When rubbed with quicklime, it exhales ammonia. Its constituents are, sal ammoniac 99.5, muriate of soda 0.5.—*Klaproth.* It occurs in the vicinity of burning beds of coal, both in Scotland and England. It is met with at Solfaterra, Vesuvius, Ætna, &c.

2. *Conchoidal.* It occurs in angular pieces, and consists of, sal ammoniac 97.5, sulphate of ammonia 2.5.—*Klaproth.* It is said to occur, along with sulphur, in beds of indurated clay or clay-slate, in the country of Bucharia.—*Jameson.* See Acid (Muriatic).

Sal Ammoniac. Muriate of ammonia.

Sal Ammoniac (Secret). Sulphate of ammonia, so called by its discoverer Glauber.

Sal Catharticus Amarus. Sulphate of magnesia.

Sal de Duobus. Sulphate of potash.

Sal Diureticus. Acetate of potash.

Sal Gem. Native muriate of soda.

Sal Glauberi. Sulphate of soda.

Sal Martis. Green sulphate of iron.

Sal Mirabile, *or* Sal Mirabile Glauberi. Sulphate of soda.

Sal Mirabile Perlatum, *or* Sal Perlatum. Phosphate of soda.

Sal Polychrest Glaseri. Sulphate of potash.

Sal Prunella. Nitrate of potash, cast into flat cakes or round balls, after fusion.

* Salifiable Bases, are the alkalis, and those earths and metallic oxides, which have the power of neutralizing acidity, entirely or in part, and producing salts.*

Saliva. The fluid secreted in the mouth, which flows in considerable quantity during a repast, is known by the name of saliva.

Saliva, beside water, which constitutes at least four-fifths of its bulk, contains the following ingredients:—

1. Mucilage,
2. Albumen,
3. Muriate of soda,
4. Phosphate of soda,
5. Phosphate of lime,
6. Phosphate of ammonia.

But it cannot be doubted, that, like all the other animal fluids, it is liable to many changes from disease, &c. Brugnatelli found the saliva of a patient labouring under an obstinate venereal disease impregnated with oxalic acid.

The concretions which sometimes form in the salivary ducts, &c. and the tartar or bony crust, which so often attaches itself to the teeth, are composed of phosphate of lime.

Salmiac. A word sometimes used for sal ammoniac.

* Salt. This term has been usually employed to denote a compound, in definite proportions, of acid matter, with an alkali, earth, or metallic oxide. When the proportions of the constituents are so adjusted, that the resulting substance does not affect the colour of infusion of litmus, or red cabbage, it is then called a neutral salt. When the predominance of acid is evinced by the reddening of these infusions, the salt is said to be acidulous, and the prefix *super,* or *bi,* is used to indicate this excess of acid. If, on the contrary, the acid matter appears to be in defect, or short of the quantity necessary for neutralizing the alkalinity of the base, the salt is then said to be with excess of base, and the prefix *sub* is attached to its name.

The discoveries of Sir H. Davy have however taught us to modify our opinions concerning saline constitution. Many bodies, such as culinary salt, and muriate of lime, to which the appellation of salt cannot be refused, have not been proved to contain either acid or alkaline matter; but must, according to the strict logic of chemistry, be regarded as compounds of chlorine with metals.

That great chemist remarks, that very few of the substances which have been always considered as neutral salts, really contain, in their dry state, the acids and alkalis from which they were formed. According to his views, the muriates and fluates must be admitted to contain neither acids, nor alkaline bases. Most of the prussiates (or prussides) are shown by M. Gay-Lussac to be in the same case. Nitric and sulphuric acids cannot be procured from the nitrates and sulphates without the intervention of bodies containing hydrogen; and if nitrate of ammonia were to be judged of from the results of its decomposition, it must be regarded as a compound of water and nitrous oxide. To this position it might perhaps be objected, that dry sulphate of iron yields sulphuric acid by ignition in a retort, while oxide of iron remains. Only those acids, says he, which are compounds of oxygen and inflammable bases, appear to enter into combination with the fixed alkalis and alkaline earths without alteration; and it is impossible to define the nature of the arrangement of the elements in their neutral compounds. The phosphate and carbonate of lime have much less of the characters attributed to neutrosaline bodies than chloride of calcium (muriate of lime), and yet this last body is not known to contain either acid or alkaline matter. M. Gay-Lussac supposes, that a chloric acid, without water or hydrogen, of one prime proportion of chlorine, and five of oxygen, exists in all the hyperoxymuriates (chlorates), but he does not support his proposition by any proof. The hyperoxymuriates were shown by Sir H. Davy, in 1811, to be composed of one prime of chlorine, one of a basis, and six of oxygen. Now hydrogen, in the liquid chloric acid of M. Gay-Lussac, may be considered as acting the part of a base; and to be exchanged for potassium in the salt hypothetically called chlorate of potash. It is an important circumstance in the law of definite proportions, that when one metallic or inflammable basis (potassium or hydrogen, for example), combines with certain proportions of a compound as hexoxygenated chlorine, all the others combine with the same proportions.

M. Gay-Lussac states, that if the chloric acid be not admitted as a pure combination of chlorine and oxygen, neither can the hydronitric or hydrosulphuric acids be admitted as pure combinations of oxygen. This is perfectly obvious. An acid, composed of five proportions of oxygen and one of nitrogen, is altogether hypothetical; and it is a simple statement of facts to say, that liquid nitric acid is a compound of one prime equivalent of hydrogen, one of azote, and six of oxygen. (Such acid has a sp. gr. considerably greater than 1.50). The only difference therefore, between nitre and hyperoxymuriate of potash, is, that one contains a prime of azote, and the other a prime of chlorine.—Thus,

Nitrate of potash.	*Chlorate of potash.*
1 prime azote,	1 prime chlorine,
6 primes oxygen,	6 primes oxygen,
1 prime potassium.	1 prime potassium.

In each, substitute hydrogen for its kindred combustible, potassium, and you have the liquid acids.

The chloriodic acid, the chlorocarbonous, and the binary acids, containing hydrogen, as muriatic and hydriodic, combine with ammonia without decomposition, but they appear to be decomposed in acting upon the fixed alkalis, or alkaline earths; and yet the solid substances they form, have all the characters which were formerly regarded as peculiar to neutral salts, consisting of acids and alkalis, though they none of them contain the acid, and only the two first of the series contain the alkalis from which they are formed. The preceding views of saline constitution, seem to be perfectly clear and satisfactory; and place in a conspicuous light, the paramount logic of the English chemist.

The solubility of salts in water, is their most important general habitude. In this menstruum they are usually crystallized; and by its agency they are purified and separated from one another, in the inverse order of their solubility. The most extensive series of experiments on the solubility of salts, which has been published, is that of Hassenfratz, contained in the 27th, 28th, and 31st volumes of the *Annales de Chimie.* Dr. Thomson has copied them into the 3d volume of his System; and I should also have willingly followed the example, were I not aware from my own researches, that several of Hassenfratz's results are erroneous. It is four years since I commenced a very extensive train of experiments on this subject, so important to the practical chemist, but unforeseen obstructions have hitherto prevented their completion. Many of Hassenfratz's determinations, however, are very nearly correct. But his statement of the relation between the density of slaked lime, and the proportion of its combined water, is so absurd, that I wonder that a person of his reputation should have published it, and that Dr. Thomson should have embodied it in his System. In one experiment, 10000 grains of lime, sp. gr.

1.5949, combined with 1620 of water, give a hydrate of sp. gr. 1.4877; and, in another, 10000 grains of lime, sp. gr. 1.3175, combined with 1875 of water, form a hydrate of sp. gr. 0.972. Four parts of lime, sp. gr. 1.4558, combined with 1 of water, are stated to yield a hydrate of sp. gr. 1.400; and with 2 of water, of specific gravity 0.8983! Now, the last proportion forms a mass greatly denser than water, instead of being much lighter than proof spirits.

"Mr. Kirwan has pointed out," says Dr. Thomson, "a very ingenious method of estimating the saline contents of a mineral water whose specific gravity is known; so that the error does not exceed one or two parts in the hundred. The method is this: —subtract the specific gravity of pure water from the specific gravity of the mineral water examined (both expressed in whole numbers), and multiply the remainder by 1.4. The product is the saline contents, in a quantity of the water, denoted by the number employed to indicate the specific gravity of distilled water. Thus, let the water be of the specific gravity of 1.079, or in whole numbers 1079. Then the specific gravity of distilled water will be 1000. And $1079 - 1000 \times 1.4 = 110.6 =$ saline contents in 1000 parts of the water in question; and, consequently, 11.06 (erroneously printed 110.6), in 100 parts of the same water." Divested of its superfluous tautology, this rule is; multiply by 140 the decimal part of the number, representing the sp. gr. of the saline solution, and the product is the dry salt in 100 grains. "This formula," adds the Doctor, "will often be of considerable use, as it serves as a kind of standard to which we may compare our analysis." *System*, vol. iii. p. 231.

In the article Caloric of this Dictionary, the reader will find the following passage:—"I did not so far violate the rules of philosophy, as to make a *general* inference from a *particular* case, a practice, it must be confessed, too common with some chemical writers." The present instance is very instructive. For Mr. Kirwan, the original author of this formula, I entertain the highest esteem. He devoted himself, with distinguished zeal, candour, and success, to the cultivation of chemistry, and when he wrote, an empirical rule like the preceding was a very pardonable error. But, at the present day, it is ridiculous to hold it forth *as a kind of standard*. With solutions of nitre and common salt, it gives tolerable approximations; and hence, I fancy that from these solutions the rule must have been framed. But for solution of sulphate of soda, this *kind of standard* gives a quantity of dry salt nearly *double*, and for that of sal ammoniac, less than *one-half* the real quantity present.

M. Gay-Lussac has recently published in the Ann. de Chimie et Phys. xi. 296, an important memoir on the solubility of salts, from which I shall make a few extracts.

One is astonished, says this excellent chemist, on perusing the different chemical works, at the inaccuracy of our knowledge respecting the solubility of the salts. They satisfy themselves with the common observation, that the salts are more soluble in hot than in cold water, and with the solubility of a few of them at a temperature usually very uncertain; yet it is upon this property of salts that their mutual decomposition, their separation, and the different processes for analyzing them depend. As a chemical process, the solution of the salts deserves peculiar attention; for though the causes to which it is due are the same as those which produce other combinations, yet their effects are not similar. It is to be wished that this interesting part of chemistry, after remaining so long in vague generalities, may at last enter the domain of experiment; and that the solubility of each body may be determined, not merely for a fixed temperature, but for variable temperatures. In the natural sciences, and especially in chemistry, general conclusions ought to be the result of a minute knowledge of particular facts, and should not precede that knowledge. It is only after having acquired this knowledge, that we can be sure of the existence of a common type, and that we can venture to state facts in a general manner.

The determination of the quantity of salt which water can dissolve is not a very difficult process. It consists in saturating the water exactly with the salt whose solubility we wish to know at a determinate temperature, to weigh out a certain quantity of that solution, to evaporate it, and weigh the saline residue. However, the saturation of water may present considerable uncertainty, and before going further, it is proper to examine the subject.

We obtain a perfectly saturated saline solution in the two following ways. By heating the water with the salt, and allowing it to cool to the temperature whose solubility is wanted; or by putting into cold water a great excess of salt, and gradually elevating the temperature. In each case, it is requisite to keep the final temperature constant for two hours at least, and to stir the saline solution frequently, to be quite sure of its perfect saturation. By direct experiments made with much care, M. Gay-Lussac ascertained that these two processes give the very same result, and that of consequence they may be employed indifferently.

Yet Dr. Thomson says, he found that water retains more oxide of arsenic when saturated by cooling, than when put in contact with the oxide without any elevation of temperature; but the reason I am persuaded was that he employed too little oxide of arsenic relatively to the water, and that he did not prolong the contact sufficiently. We perceive in fact, on a little reflection, that saturation follows in its progress a decreasing geometrical progression, and that the time necessary for completing it depends upon the surface of contact of the solvent and the body to be dissolved.

It happens often that the solution of a salt which does not crystallize, and which, for that reason, we consider as saturated, yields saline molecules to the crystals of the same nature plunged into it; and it has been concluded from this, that the crystals of a salt impoverish a solution, and make it sink below its true point of saturation. The fact is certain; it is even very general; but I am of opinion that it has been ill explained.

Saturation in a saline solution of an invariable temperature, is the point at which the solvent, always in contact with the salt, can neither take up any more, nor let go any more. This point is the only one which should be adopted, because it is determined by chemical forces, and because it remains constant as long as these forces remain constant. According to this definition, every saline solution which can let go salt without any change of temperature is of necessity supersaturated. It may be shown that, in general, supersaturation is not a fixed point, and that the cause which produces it, is the same as that which keeps water liquid below the temperature at which it congeals.

"I shall now give an account of the experiments which I have made on the solubility of the salts.

"Having saturated water with a salt at a determinate temperature, as I have explained above, I take a matrass capable of holding 150 to 200 grammes of water, and whose neck is 15 to 18 centimetres in length. After having weighed it empty, it is filled to about a fourth part with the saline solution, and weighed again. To evaporate the water, the matrass is laid hold of by the neck by a pair of pincers, and it is kept on a red-hot iron at an angle of about 45°, taking care to move it continually, and to give the liquid a rotatory motion, in order to favour the boiling, and to prevent the violent bubbling up which is very common with some saline solutions, as soon as, in consequence of evaporation, they begin to deposite crystals. When the saline mass is dry, and when no more aqueous vapours are driven off at a heat nearly raised to redness, I blow into the matrass by means of a glass tube fitted to the nozzle of a pair of bellows, in order to drive out the aqueous vapour which fills it. The matrass is then allowed to cool, and weighed. I now know the proportion of water to the salt held in solution, and this is expressed by representing the quantity of water to be 100. Each of the following results is the mean of at least two experiments:—

Solubility of Chloride of Potassium.

Temperature centigrade.	*Chloride dissolved by* 100 *water.*
0.00°	29.21
19.35	34.53
52.39	43.59
79.58	50.93
109.60	59.26

Solubility of Chloride of Barium.

Temperature centigrade.	*Salt dissolved in* 100 *water.*
15.64°	34.86
49.31	43.84
74.89	50.94
105.48	59.58"

In these experiments, the chloride of barium is supposed to be anhydrous; but as when it is crystallized it retains two proportions of water, 22.65, for one of chloride, 131.1, we must of necessity, in order to compare its solubility with that of other salts, increase each number of solubility by the same number multiplied into the ratio of 22.65 to 131.1, and diminish by as much the quantity of water. On making this correction, the preceding results will be changed into the following:—

Temperature.	*Salt diss. in* 100 *water.*
15.64°	43.50
49.31	55.63
74.89	65.51
105.48	77.89

Solubility of Chloride of Sodium.

Temperature.	*Salt diss. in* 100 *water.*
13.89°	35.81
16.90	35.88
59.93	37.14
109.73	40.38

Solubility of Sulphate of Potash.

Temperature.	*Salt diss. in* 100 *water.*
12.72°	10.57
49.08	16.91
63.90	19.29
101.50	26.33

Solubility of Sulphate of Magnesia.

Temperature.	*Salt diss. in* 100 *water.*
14.58°	32.76
39.86	45.05
49.08	49.18
64.35	56.75
97.03	72.30

The sulphate of magnesia is here supposed anhydrous; but as it crystallizes retaining seven portions of water, 79.3, for one proportion of salt, 74.6, each number which expresses the solubility, must be increased by this number multiplied by the ratio of 79.3 to 74.6, and the corresponding quantity of water diminished as much. We shall thus have for the solubility of crystallized sulphate of magnesia the following results:—

Temperature.	
14.58°	103.69
39.86	178.34
49.08	212.61
64.35	295.13
97.03	644.44

These results are no longer proportional to the temperatures; they augment in a much greater ratio.

Solubility of Sulphate of Soda.

	Salt soluble in 100 water.	
Temperature.	*Anhydrous.*	*Crystallized.*
0.00°	5.02	12.17
11.67	10.12	26.38
13.30	11.74	31.33
17.91	16.73	48.28
25.05	28.11	99.48
28.76	37.35	161.53
30.75	43.05	215.77
31.84	47.37	270.22
32.73	50.65	322.12
33.88	50.04	312.11
40.15	48.78	291.44
45.04	47.81	276.91
50.40	46.82	262.35
59.79	45.42	——
70.61	44.35	——
84.42	42.96	——
103.17	42.65	——

We see by these results, that the solubility of sulphate of soda follows a very singular law. After having increased rapidly to about the temperature of 33°, where it is at its maximum, it diminishes to 103.17°, and at that point it is nearly the same as at 30.5.° The sulphate of soda presents the second example of a body whose solubility diminishes as the temperature augments; for Mr. Dalton has already observed the same property in lime.

Solubility of Nitrate of Barytes.

Temperature.	*Salt diss. in 100 water.*
0.00°	5.00
14.95	8.18
17.62	8.54
37.87	13.67
49.22	17.07
52.11	17.97
73.75	25.01
86.21	29.57
101.65	35.18

Solubility of Nitre.

Temperature.	*Salt diss. in 100 water.*
0.00°	13.32
5.01	16.72
11.67	22.23
17.91	29.31
24.94	38.40
35.13	54.82
45.10	74.66
54.72	97.05
65.45	125.42
79.72	169.27
97.66	236.45

Solubility of Chlorate of Potash.

Temperature.	
0.00°	3.33
13.32	5.60
15.37	6.03
24.43	8.44
35.02	12.05
49.08	18.96
74.89	35.40
104.78	60.24

Plate VIII. exhibits a perpendicular section through the middle of the salt mine of Visachna, on the south-west of the Carpathian mountains.

1. A stratum of vegetable mould.
2. Stiff yellow clay.
3. Gray and yellow clay, mixed with spots and veins of sand and ochre.
4. Grayish-blue clay.
5. Fine white sand.
6. Black, fat, bituminous clay, immediately covering the bed of salt.
7. The body of salt, divided into inclined strata. This has been penetrated to the depth of about two hundred yards. It is traversed by veins (8, 8,) of a bituminous clay, of the same nature as that at 6. This clay contains sulphate of lime.

A. The shaft by which the salt is drawn up.

C. The shaft through which the workmen pass up and down by means of a ladder placed in it.

D. A shaft that receives the rain-water, and conducts it to the drain F.

B. A shaft that receives rain-water, and conducts it into the gallery E.

E, E, F. Sections of two circular galleries surrounding the shafts A and C, which collect the waters that penetrate between the strata of clay, and conduct them to the drain F, through which they are carried off.

H, H. A conical space hollowed out of the rock salt in working it.

a, a, a, a. Pieces of timber driven into the bed of salt, and supporting all the woodwork of the shafts.

b, b, b, b. Sheep-skins, nailed on these pieces of timber, to keep them from wet.

c, c. Bags in which the salt is drawn up.

d, d, d. Cuts for extracting the salts in oblong squares.

e, e. Blocks of salt ready to be put into the bags and drawn up.

When this salt is impure, it must be dissolved in water, in order to purify it.

The water of the ocean contains our most ample store of salt, but not the richest. If we had no means of obtaining the muriate of soda from it, but by the heat of fires, salt would be an expensive article of consumption. Recourse, therefore, has been had to two methods of attaining this purpose: 1st, by natural evaporation; 2d, by natural and artificial evaporation combined.

In the first case, the salt is extracted by means of brine-pits. These are large shallow pits, the bottom of which is very smooth, and formed of clay. They are made near the sea-shore, and consist of,

1st, A large reservoir, deeper than the proper brine-pits, and dug between them and the sea. This reservoir communicates with the sea by means of a channel provided with a sluice. On the sea-shore, these reservoirs may be filled at high water, but the tides are rather inconvenient than advantageous to brine-pits.

2dly, The brine-pits properly so called, which are divided into a number of compartments by means of little banks. All these compartments have a communication with each other, but so that the water frequently has a long circuit to make from one set to another. Sometimes it has four or five hundred yards to flow before it reaches the extremity of this sort of labyrinth. The various divisions have a number of singular names, by which they are technically distinguished, and differing much in different places.

The brine-pits should be exposed to the north, north-east, or north-west winds.

Plate IX. exhibits a plan of a set of brine-pits.

A, A. The great reservoir, into which the water flows through the sluice *a*.

B, B, B. The second reservoir. Into this the water enters by a subterranean channel at *b*, and, circulation through the several divisions in the direction of the shaded line, finds its exit at *d*.

c, c, c, c. Narrow banks of earth separating the divisions.

C, C, C. The third reservoir. The water, on quitting the second reservoir, enters, through an aperture at *d*, the long narrow channel *d*, *e*, *f*, *g*, *h*, whence it flows into C, C, C, as it had before done into B, B, B.

D, D, D, D. The fourth reservoir, into which the water flows, as shown in the plate, from the third reservoir; and from which it is ultimately distributed among the small square basins E, E, E, E, E, E, E, E.

i, *i*, *i*, *i*. Heaps of salt drawn out of the basins E, E, and left to drain.

K, K. The salt collected together in larger heaps, and left to drain still more.

The water of the sea is let into these reservoirs in the month of March. It affords, as is apparent, a vast surface for evaporation. The first reservoir is intended to detain the water till its impurites have subsided, while at the same time the evaporation commences in it. From this the other reservoirs are supplied, as their water evaporates. The salt is considered as on the point of crystallizing, when the water begins to grow red. Soon after this, a pellicle forms on the surface, which breaks, and falls to the bottom. Sometimes the salt is allowed to subside in the first compartment, sometimes it is made to pass on to others, where a larger surface is exposed to the air. In either case the salt is drawn out, and left upon the borders of the pans to drain and dry. In this way it is collected two or three times a-week, toward the end of the operation.

The salt thus obtained, partakes of the colour of the bottom on which it is formed; according to the nature of which, it is white, red, or gray. The last is frequently called green salt. Sea-salt has the inconvenience of tasting bitter, if used immediately after it is made. This is owing to the muriate of lime and sulphate of soda, with which it is contaminated. By exposure to the air for two or three years it is in part freed from these salts.

Explanation of Plates X. and XI.

Fig. 1. Plan of the salt pans.
No. 1. Small pan.
No. 2. Graduating pan.
No. 3. Preparing pan.
No. 4. Crystallizing pan.

The arrangement of the plates of iron, which compose these pans, is shown in No. 2.

a, *a*. Elevation on which the salt is placed to drain, as it is taken from the crystallizing pans.

b, *b*, *b*. Wooden partitions, which separate the chambers.

c, *c*, *c*. A raised wooden ledge, which surrounds the pans.

Fig. 2. Section of the evaporating chamber, which contains the pans 1 and 2, in the line C, D.

d, *d*, *d*. Heat-tubes, which give heat to the small pan, and contribute to heat the others.

e, *e*, *e*. Fire-place for the pans.

i, *i*, *i*. Pillars of cast iron, over the gratings *g*, *g*, *g*, which support the bottoms of the pans.

h. Wooden chamber, which contains the two pans.

k. Opening by which the vapours escape.

Fig. 3. Section of the evaporating chamber, which contains the pans 3 and 4, in the line A, B.

a. Elevation on which the salt from the crystallizing pans is placed to drain.

The other letters indicate the same parts as in the preceding figures.

Fig. 4. Method in which the plates of iron are joined to form the pans.

a. The iron plate.

b. The iron gutter, which receives the edges of the plates, and is strongly fastened with screws.

i, *i*. Pillars of cast iron, which support the bottom of the pan.

Sometimes the water is evaporated to dryness; but this is rarely done, because for this the water must contain no muriate of soda. Commonly the mother-water is left, containing chiefly the deliquescent salts, which are muriates of lime and magnesia. These salts, while they increase the bulk of the mother-water, add also to the consumption of fuel, and render the salt obtained bitter and deliquescent.

When saline waters contain but a small quantity of salt, the evaporation of it by fire in its natural state would be too expensive. It must be concentrated therefore by some cheaper mode.

Now it is well known, that, to promote and accelerate the evaporation of a fluid, it should be made to present a large surface to the air. To effect this, the water is pumped up to the height of nine or ten yards, and made to fall on piles of faggots built up in the shape of a wall. The water, distributed uniformly over these by means of troughs, is minutely divided in its descent, and thus experiences a considerable evaporation. The same water is frequently pumped up twenty times or more, to bring it to the degree of concentration necessary. This operation is called *graduating*, and the piles of thorn faggots thus erected are termed *graduation houses*.

These piles are covered with a roof, to shelter them from the rain, are made about five yards thick, and are sometimes more than four hundred yards long. They should be so constructed that their sides may face the prevailing winds.

Plate XII. represents a graduation house at Bex, with the improvements lately made in it by M. Fabre.

A. Transverse section of the building.

B. Longitudinal section.

c, *c*, *c*. The faggots of thorns, piled up in two tiers below, and one above.

a, *a*. Wooden troughs, to distribute the salt water over these faggots.

C, C. Plan and perspective view of these troughs.

b, *b*, *b*. Angular notches, through which the water runs out in slender streams, presenting a large surface to the air.

e. Roof, covered with tiles, not laid flat, but raised so as to admit a free circulation of air between them.

d, *d*. Reservoir, into which the concentrated salt water flows, and from which it is pumped up to the troughs, to be distributed afresh over the faggots.

The state of the air has a considerable influence on the celerity of the concentration. A cool, dry, and moderate wind is favourable to it; while dull, damp, and foggy weather sometimes even adds to the quantity of water.

The principal uses of the muriate of soda have already been mentioned under the article *muriatic acid*. In addition it may be observed, that almost all graminivorous animals are fond of it, and that it appears to be beneficial to them, when mixed with their food. Wood steeped in a solution of it, so as to be thoroughly impregnated with it, is very difficult of combustion: and in Persia it is supposed to prevent timber from the attack of worms, for which purpose it is used in that country. Bruce informs us, that in Abyssinia it is used as money; and it is very probable, that the pillars of fossil glass, in which the Abyssinians are said by Herodotus to have enclosed the bodies of their relations, were nothing but masses of rock salt, which is very common in that part of Africa.

Salt was supposed by the ancients to be so detrimental to vegetation, that, when a field was condemned to sterility, it was customary to sow it with salt. Modern agriculturists, however, consider it as a useful manure.

* We are indebted to Dr. Henry for a very able and elaborate investigation of the different varieties of common salt. The following table contains the general statement of his experiments.

1000 *parts by weight consist of*

	Kind of salt.	*Insol. matter.*	*Mur. lime.*	*Mur. magn.*	*Total earthy mur.*	*Sulph. lime.*	*Sulph. magn.*	*Total Sulphs.*	*Total muriates.*	*Pure muriate of soda.*
For. bay salt	St. Ube's,	9	*trace*	3	3	23½	4½	28	40	960
	St. Martin's,	12	do.	3½	3½	19	6	25	40½	959½
	Oleron,	10	do.	2	2	19½	4½	23¾	35¾	964¼
Brit. salt fr. sea-water.	Scotch (common),	4	—	28	28	15	17½	32½	64	935½
	Scotch (Sunday),	1	—	11½	11½	12	4½	16½	29	971
	Lymington(common)	2	—	11	11	15	35	50	63	937
	Ditto (cat),	1	—	5	5	1	5	6	12	988
Cheshire salt.	Crushed rock,	10	$0.\frac{1}{16}$	$0.\frac{3}{16}$	0.¼	6½	—	6½	16¾	983¼
	Fishery,	1	0.¼	0.¾	1	11¼	—	11¼	13¼	986¾
	Common,	1	0.¼	0.¾	1	14½	—	14½	16½	983½
	Stoved,	1	0.¼	0.¾	1	15½	—	15½	17½	982½

"In sea salt prepared by rapid evaporation, the insoluble portion is a mixture of carbonate of lime with carbonate of magnesia, and a fine siliceous sand; and in the salt prepared from Cheshire brine, it is almost entirely carbonate of lime. The insoluble part of the less pure pieces of rock salt is chiefly a marly earth, with some sulphate of lime. The quantity of this impurity, as it is stated in the table, is considerably below the average, which in my experiments has varied from 10 to 45 parts in 1000. Some estimate of its general proportion, when ascertained on a larger scale, may be formed from the fact, that government, in levying the duties, allow 65 pounds to the bushel of rock salt, instead of 56 pounds, the usual weight of a bushel of salt."—*Henry.* Phil. Trans. for 1810, part 1st. The enormous contamination of the Scotch variety with that septic bitter salt, muriate of magnesia, accords perfectly with my own experiments, and is a reproach to the country.

"That kind of salt then," says this able chemist, "which possesses most eminently the combined properties of hardness, compactness, and perfection of crystals, will be best adapted to the purpose of packing fish and other provisions; because it will remain permanently between the different layers, or will be very gradually dissolved by the fluids that exude from the provisions; thus furnishing a slow but constant supply of saturated brine. On the other hand, for the purpose of preparing the pickle, or of striking the meat, which is done by immersion in a saturated solution of salt, the smaller grained varieties answer equally well; or, on account of their greater solubility, even better," provided they be equally pure. His experiments show, that in compactness of texture the large grained British salt is equal to the foreign bay salt. Their antiseptic qualities are also the same.*

SALT (AMMONIACAL, FIXED). Muriate of lime.

SALT (AMMONIACAL, SECRET) of Glauber. Sulphate of ammonia.

SALT (ARSENICAL, NEUTRAL) of Macquer. Superarseniate of potash.

SALT (BITTER, CATHARTIC). Sulphate of magnesia.

SALT (COMMON). Muriate of soda. See ACID (MURIATIC): also end of the article SALT, and ROCK SALT.

SALT (DIGESTIVE) OF SYLVIUS. Acetate of potash.

SALT (DIURETIC). Acetate of potash.

SALT (EPSOM). Sulphate of magnesia.

SALT (FEBRIFUGE) OF SYLVIUS. Muriate of potash.

SALT (FUSIBLE). Phosphate of ammonia.

SALT (FUSIBLE) OF URINE. Triple phosphate of soda and ammonia.

SALT (GLAUBER'S). Sulphate of soda.

SALT (GREEN). In the mines of Wieliczka the workmen give this name to the upper stratum of native salt, which is rendered impure by a mixture of clay.

SALT (MARINE). Muriate of soda.

SALT (MARINE, ARGILLACEOUS). Muriate of alumina.

SALT (MICROCOSMIC). Triple phosphate of soda and ammonia.

SALT (NITROUS AMMONIACAL). Nitrate of ammonia.

SALT OF AMBER. Succinic acid.

SALT OF BENZOIN. Benzoic acid.

SALT OF CANAL. Sulphate of magnesia.

SALT OF COLCOTHAR. Sulphate of iron.

SALT OF EGRA. Sulphate of magnesia.

SALT OF LEMONS (ESSENTIAL). Superoxalate of potash.

SALT OF SATURN. Acetate of lead.

Salt of Sedlitz. Sulphate of magnesia.

Salt of Seignette. Triple tartrate of potash and soda.

Salt of Soda. Subcarbonate of soda.

Salt of Sorrel. Superoxalate of potash.

Salt of Tartar. Subcarbonate of potash.

Salt of Vitriol. Purified sulphate of zinc.

Salt of Wisdom. A compound muriate of mercury and ammonia. See Alembroth.

Salt (Perlate). Phosphate of soda.

Salt (Polychrest) of Glaser. Sulphate of potash.

Salt (Sedative). Boracic acid.

Salt (Spirit of). Muriatic acid was formerly called by this name, which it still retains in commerce.

Salt (Sulphureous) of Stahl. Sulphite of potash.

Salt (Wonderful). Sulphate of soda.

Salt (Wonderful Perlate). Phosphate of soda.

Saltpetre. Nitrate of potash.

Sand. Sand is an assemblage of small stones.

Sand-bath. See Bath.

Sandaric Gum. A resin in yellowish-white tears, possessing a considerable degree of transparency.

Sandiver, or Glass-gall. This is a saline matter, which rises as a scum in the pots or crucibles in which glass is made.

* **Sanguification.** That process of living animals by which chyle is converted into blood. I had entertained hopes of being able to present some definite facts on this mysterious subject, but have been disappointed. The latest and best essay on sanguification is that of Dr. Prout, in the Annals of Philosophy for April 1819.*

* **Sappare.** Cyanite.*

* **Sapphire.** A sub-species of rhomboidal corundum. It is the *Telesie* of Haüy, and the *perfect corundum* of Bournon. The oriental ruby and topaz are sapphires.

Colours blue and red; it occurs also gray, white, green, and yellow. It occurs in blunt edged pieces, in roundish pebbles, and crystallized. The primitive figure is a slightly acute rhomboid, or double three-sided pyramid, in which the alternate angles are 86° 4′ and 93° 56′. The following are the usual forms:—a very acute, equiangular, six-sided pyramid; the same truncated on the summit; a perfect six-sided prism; an acute, double, six-sided pyramid; the same acuminated, or truncated in various ways. Splendent, inclined to adamantine. Cleavage parallel with the terminal planes of the prism. Fracture conchoidal. From transparent to translucent. Refracts double. After diamond, it is the hardest substance in nature. The blue variety or sapphire, is harder than the ruby. Brittle. Sp. gr. 4 to 4.2. Its constituents are,

	Blue.	*Red.*
Alumina,	98.5	90.0
Lime,	0.5	7.0
Oxide of iron,	1.	1.2
loss		1.8
	100.0	100.0
	Klaproth.	*Chenevix.*

Infusible before the blow-pipe. It becomes electrical by rubbing, and retains its electricity for several hours; but does not become electrical by heating. It occurs in alluvial soil, in the vicinity of rocks belonging to the secondary or floetz-trap formation, and imbedded in gneiss. It is found at Podsedlitz and Treblitz in Bohemia, and Hohenstein in Saxony; Expailly in France; and particularly beautiful in the Capelan mountains, 12 days journey from Sirian a city of Pegu. Next to diamond, it is the most valuable of the gems. The white and pale blue varieties, by exposure to heat, become snow-white, and when cut exhibit so high a degree of lustre, that they are used in place of diamond. The most highly prized varieties are the crimson and carmine-red; these are the oriental *ruby* of the jeweller; the next is *sapphire*, and last, the yellow, or oriental *topaz*. The *asterias* or star-stone, is a very beautiful variety, in which the colour is generally of a reddish-violet, and the form a rhomboid, with truncated apices, which exhibit an opalescent lustre. A sapphire of 10 carats weight, is considered to be worth fifty guineas.—*Jameson.**

* **Saphirin.** Haüyne.*

* **Sarcolite.** A variety of analcime.*

* **Sarde, or Sardoin,** a variety of carnelian, which displays on its surface an agreeable and rich reddish-brown colour, but appears of a deep blood-red, when held between the eye and the light.*

* **Sardonyx.** Another variety, composed of layers of white and red carnelian.*

* **Sassoline.** Native boracic acid. It is found on the edges of hot springs near Sasso, in the territory of Florence. It consists of boracic acid 86, ferruginous sulphate of manganese 11, sulphate of lime 3.—*Klaproth.**

* **Satin Spar.** Fibrous limestone; which see.*

Saturation. Some substances unite in all proportions. Such, for example, are acids in general, and some of the salts with water; and many of the metals with each other. But there are likewise many substances which cannot be dissolved in a fluid, at a settled temperature, in any quantity beyond a certain proportion. Thus water will dissolve only about one-third of its weight of common salt; and, if more be added, it will remain solid. A fluid, which holds in solution as much of any substance as it can dissolve, is said to be saturated with it. But saturation with one substance does not deprive the fluid of its power of acting on and dissolving some other bodies, and in many cases it increases this power. For example, water saturated with salt will dissolve sugar; and water saturated with carbonic acid will dissolve iron, though without this addition its action on this metal is scarcely perceptible.

The word saturation is likewise used in another sense by chemists: the union of two principles produces a body, the properties of which differ from those of its component parts, but resemble those of the predominating principle. When the principles are in such proportion that neither predominates, they are said to be saturated with each other; but if otherwise, the most predominant principle is said to be sub-saturated or undersaturated, and the other supersaturated or oversaturated.

* SAUSSURITE. Colours white, gray, and green. Massive, disseminated, and in rolled pieces. Dull. Fracture splintery. Faintly translucent on the edges. Difficultly frangible. Hard, scratching quartz. Meagre to the feel. Sp. gr. 3.2. It melts on the edges and angles. Its constituents are, silica 49, alumina 24, lime 10.5, magnesia 3.75, natron 5.5, iron 6.5—*Klaproth.* It occurs at the foot of Mount Rosa. Professor Jameson places it near Andalusite.*

* SCALES OF FISH, consist of alternate layers of membrane and phosphate of lime.*

* SCALES OF SERPENTS, are composed of a horny membrane, without the calcareous phosphate.*

* SCAMMONY consists of

	Aleppo.	*Smyrna.*
Resin,	60	29
Gum,	3	8
Extractive,	2	5
Vegetable debris and earth,	35	58
	100	100

*Vogel, and Bouillon Lagrange.**

* SCAPOLITE, OR PYRAMIDAL FELDSPAR. Professor Jameson divides it into four sub-species; radiated, foliated, compact red, and elaolite.

1. *Radiated.* Colour gray. Massive, in distinct concretions and crystallized. Primitive figures a pyramid of 136° 38′ and 62° 56′. The secondary forms are, a rectangular four-sided prism, acuminated or truncated. Lateral planes deeply longitudinally streaked. Resinous, pearly. Cleavage double. Fracture fine grained uneven. Translucent. As hard as apatite. Easily frangible. Sp. gr. 2.5 to 2.8. Green scapolite becomes white before the blow-pipe, and melts into a white glass. Its constituents are, silica 45, alumina 33, lime 17.6, natron 1.5, potash 0.5, iron and manganese 1.—*Laugier.* It occurs in the neighbourhood of Arendal in Norway, associated with magnetic ironstone, feldspar, &c.

2. *Foliated scapolite.* Colours gray, green, and black. Massive, disseminated, and crystallized in low eight-sided prisms, flatly acuminated with four planes. Splendent, vitreous. Fracture small grained uneven. Translucent. Streak white. Brittle. Hardness and sp. gr. as preceding species. It is found in granular granite or *whitestone*, in the Saxon Erzegebirge.

3. *Compact scapolite.* Colour red. Crystallized in long, acicular, four-sided prisms, which are often curved. Glistening. Opaque. Hard in a low degree. Easily frangible. It occurs with the others in metalliferous beds at Arendal.

4. See ELAOLITE.*

* SCHAALSTEIN. See TABULAR SPAR.*

* SCHAUM EARTH. See APHRITE.*

* SCHEELIUM. Tungsten.*

* SCHIEFER SPAR. See SLATE SPAR.*

* SCHILLER SPAR. This species contains two sub-species; bronzite and common schiller spar. See BRONZITE.*

Common schiller spar. Colour olive green. Disseminated, and in granular distinct concretions. Splendent and metallic-pearly. Cleavage single. Opaque. Softer than bronzite. Streak greenish gray. Easily frangible. Sp. gr. 2.882? It occurs imbedded in serpentine in Fetlar and Unst in Shetland, and at Portsoy in Banffshire; also in Skye, Fifeshire, Calton-hill, near Dumbarton, between Ballantrae and Girvan in Ayrshire, and in Cornwall.

Labradore schiller spar. See HYPERSTENE.*

* SCILLITIN. A white transparent, acrid substance, extracted from squills; by Vogel.*

* SCHMELZSTEIN. Dipyre.*

* SCHORL (COMMON). A sub-species of rhomboidal tourmaline. Colour velvet-black. Massive, disseminated, and crystallized in three, six, and nine-sided prisms. Crystals acicular. Lateral planes, longitudinally streaked. Between shining and glistening. Fracture conchoidal, or uneven. Opaque. Streak gray. As hard as quartz. Easily frangible. Sp. gr. 3. to 3.3. It melts into a blackish slag. Its constituents are, silica 36.75, alumina 34.5, magnesia 0.25, oxide of iron 21, potash 6, and a trace of manganese.—*Klaproth.* It exhibits the same electric properties as tourmaline. It occurs imbedded in granite, gneiss, &c. in Perthshire, Banffshire, Cornwall, &c.*

* SCHORL (BLUE). A variety of Haüyne.*

* SCHORL (RED AND TITANITIC). Rutile.*

* **SCHORLITE, or SCHORLOUS TOPAZ.** *Pycnite* of Werner. Colour, straw-yellow. Massive, composed of parallel prismatic concretions, and crystallized in long six-sided prisms. Glistening, resinous. Fracture, small conchoidal. Translucent on the edges. Nearly as hard as common topaz. Brittle. Sp. gr. 3.53. Infusible. Becomes electric by heating. Its constituents are, alumina 51, silica 38.43, fluoric acid 8.84. —*Berzelius*. It occurs at Altenburg in Saxony, in a rock of quartz and mica, in porphyry.*

* **SELENIUM.** A new elementary body, extracted by M. Berzelius from the pyrites of Fahlun, which, from its chemical properties, he places between sulphur and tellurium, though it has more properties in common with the former than with the latter substance. It was obtained in exceedingly small quantity from a large portion of pyrites. For the mode of extraction I must refer to his long and elaborate papers, translated from the Annales de Chimie et Physique, ix. *et seq.* into the Annals of Philosophy, for June, August, October, and December 1819, and January 1820.

When selenium, after being fused, becomes solid, its surface assumes a metallic brilliancy of a very deep brown colour, resembling polished hæmatites. Its fracture is conchoidal, vitreous, of the colour of lead, and perfectly metallic. The powder of selenium has a deep red colour, but it sticks together readily when pounded, and then assumes a gray colour and a smooth surface, as happens to antimony and bismuth. In very thin coats, selenium is transparent, with a ruby-red colour. When heated it softens; and at 212° it is semi-liquid, and melts completely at a temperature a few degrees higher. During its cooling it retains for a long time a soft and semi-fluid state. Like Spanish wax, it may be kneaded between the fingers, and drawn out into long threads, which have a great deal of elasticity, and in which we easily perceive the transparency, when they are flat and thin. These threads, viewed by transmitted light, are red; but, by reflected light, they are gray, and have the metallic lustre.

When selenium is heated in a retort, it begins to boil at a temperature below that of a red heat. It assumes the form of a dark yellow vapour, which, however, is not so intense as that of the vapour of sulphur; but it is more intense than chlorine gas. The vapour condenses in the neck of the retort, and forms black drops, which unite into larger drops, as in the distillation of mercury.

If we heat selenium in the air, or in vessels so large, that the vapour may be condensed by the cold air, a red smoke is formed, which has no particular smell, and which is condensed in the form of a cinnabar-red powder, yielding a species of flowers, as happens to sulphur in the same circumstances. The characteristic smell of horse-radish is not perceived, till the heat becomes great enough to occasion oxidation.

Selenium is not a good conductor of heat. We can easily hold it between the fingers, and melt it at the distance of one or two lines from the fingers, without perceiving that it becomes hot. It is also a non-conductor of electricity. On the other hand, M. Berzelius was not able to render it electric by friction. It is not hard; the knife scratches it easily. It is brittle like glass, and is easily reduced to powder. Its sp. gr. is between 4.3 and 4.32.

The affinity of selenium for oxygen is not very great. If we heat it in the air, without touching it with a burning body, it is usually volatilized without alteration; but if it is touched by flame, its edges assume a fine sky-blue colour, and it is volatilized with a strong smell of horse-radish. The odorous substance is a gaseous oxide of selenium, which, however, has not been obtained in an insulated state, but only mixed with atmospherical air. If we heat selenium in a close phial filled with common air, till the greatest part of it is evaporated, the air of the phial acquires the odour of oxide of selenium in a very high degree. If we wash the air with pure water, the liquid acquires the odour of the gas; but as there are always formed traces of selenic acid, this water acquires the property of reddening litmus paper feebly, and of becoming muddy when mixed with sulphuretted hydrogen gas. Selenic oxide gas is but very little soluble in water, and does not communicate any taste to it.

If we heat selenium in a large flask filled with oxygen gas, it evaporates without combustion, and the gas assumes the odour of selenic oxide, just as would have happened, if the sublimation had taken place in common air; but if we heat the selenium in a glass ball of an inch diameter, in which it has not room to volatilize and disperse; and if we allow a current of oxygen gas to pass through this ball, the selenium takes fire, just when it begins to boil, and burns with a feeble flame, white towards the base, but green or greenish-blue at the summit, or towards the upper edge. The oxygen gas is absorbed, and selenic acid is sublimed into the cold parts of the apparatus. The selenium is completely consumed without any residue. The excess of oxygen gas usually assumes the odour of selenic oxide. Selenic acid is in the form of very long four-sided needles. It seems to be most readily formed by the action of nitro-muriatic acid on selenium. The selenic acid does not melt with heat; but it diminishes a little in bulk at the hottest place, and then assumes the gaseous form. It absorbs a little moisture from the air, so that the crystals adhere to each other, but they do not deliquesce. It has a pure acid taste, which leaves a slightly burning sensation on the tongue. It is very soluble in cold water, and dissolves in almost every proportion in boiling water. M. Berzelius infers the composition of selenic acid, from several experiments, to be,

Selenium,	71.261	100.00	1 prime	4.96
Oxygen,	28.739	40.33	2 primes	2.00

If into a solution of selenic acid in muriatic acid, we introduce a piece of zinc or of polished iron, the metal immediately assumes the colour of copper, and the selenium is gradually precipitated in the form of red, or brown or blackish flocks, according as the temperature is more or less elevated. When seleniate of potash is heated with muriate of ammonia, selenium is obtained by the deoxidating property of the ammonia; but in this case we always lose a small quantity of selenium, which comes over with the water in the form of an acid. If we pour dilute muriatic acid on the compound of selenium and potassium dissolved in water, seleniuretted hydrogen gas is evolved. Water impregnated with it precipitates all the metallic solutions, even those of iron and zinc, when they are neutral. Sulphur, phosphorus, the earths, and the metals combine with selenium, forming seleniurets. Selenic acid neutralizes the bases. Selenium has been recently found in two minerals, one is from Skrickerum, in the parish of Tryserum in Smoland.*

* **Scorza.** A variety of epidote.*

* **Sea Froth.** *Meerschaum.**

Sea Salt. Muriate of soda. See **Acid (Muriatic)**, and **Salt.**

* **Sea Wax.** Maltha, a white, solid, tallowy looking fusible substance, soluble in alcohol, found on the Baikal Lake in Siberia.*

* **Sebacic Acid.** See **Acid (Sebacic)**.*

Sebate. A neutral compound of sebacic acid with a base.

Sedative Salt. Boracic acid.

Sel de Seignette. The triple tartrate of potash and soda, or Rochelle salt. See **Acid (Tartaric).**

* **Selenite.** Sparry gypsum.*

* **Semiopal.** See **Opal.***

* **Septaria,** or *ludi helmontii*, are spheroidal concretions that vary from a few inches to a foot in diameter. When broken in a longitudinal direction, we observe the interior of the mass intersected by a number of fissures, by which it is divided into more or less regular prisms, of from 3 to 6 or more sides, the fissures being sometimes empty, but oftener filled up with another substance, which is generally calcareous spar. The body of the concretion is a ferruginous marl. From these septaria are manufactured that excellent material for building under water, known by the name of Parker's or Roman cement.—*Jameson.**

* **Serosity.** See **Blood.***

* **Serpentine;** common and precious.

1. *Common.* Colour green, of various shades. Massive. Dull. Fracture, small and fine splintery. Translucent on the edges. Soft, and scratched by calcareous spar. Sectile. Difficultly frangible. Feels somewhat greasy. Sp. gr. 2.4 to 2.6. Some varieties are magnetic. Its constituents are, silica 32, magnesia 37.24, alumina 0.5, lime 10.6, iron 0.66: volatile matter and carbonic acid 14.16.—*Hisinger*. John and Rose give 10.5 of water in it. It occurs in various mountains. It is found in Unst and Fetlar in Shetland; at Portsoy; between Ballantrae and Girvan; in Cornwall; and in the county of Donegal.

2. *Precious serpentine.* Of this there are two kinds, the splintery and conchoidal.

a. Splintery. Colour dark leek-green. Massive. Feebly glimmering. Fracture coarse splintery. Feebly translucent. Soft. Sp. gr. 2.7. It occurs in Corsica, and is cut into snuff-boxes, &c.

b. Conchoidal. Colour leek-green. Massive and disseminated. Glistening, resinous. Fracture flat conchoidal. Translucent. Semi-hard. Sp. gr. 2.6. Its constituents are, silica 42.5, magnesia 38.63, lime 0.25, alumina 1, oxide of iron 1 5, oxide of manganese 0.62, oxide of chrome 0.25, water 15.2.—*John.* It occurs with foliated granular limestone in beds subordinate to gneiss, mica-slate, &c. It is found at Portsoy, in Banffshire; in the Shetland Islands, and in the Island of Holyhead. It receives a finer polish than common serpentine.*

* **Serum.** See **Blood** and **Milk.***

* **Shale.** *Slate-clay and bituminous slate-clay.**

Shells. Marine shells may be divided, as Mr. Hatchett observes, into two kinds: Those that have a porcellanous aspect, with an enamelled surface, and when broken are often in a slight degree of a fibrous texture; and those that have generally, if not always, a strong epidermis, under which is the shell, principally or entirely composed of the substance called nacre, or mother-of-pearl.

The porcellanous shells appear to consist of carbonate of lime, cemented by a very small portion of animal gluten. This animal gluten is more abundant in some, however, as in the patellæ.

The mother-of-pearl shells are composed of the same substances. They differ, however, in their structure, which is lamellar, the gluten forming their membranes, regularly alternating with strata of carbonate of lime. In these too the gluten is much more abundant.

Mr. Hatchett made a few experiments on land shells also, which did not exhibit any differences. But the shells of the crustaceous animals he found to contain more or less phosphate of lime, though not equal in quantity to the carbonate, and hence approaching to the nature of bone. Linnæus therefore he observes was right in considering the covering of the echini as crustaceous, for it contains phosphate of lime. In the covering of some of the species of asterias too, a little phosphate of lime occurs; but in that of others there is none. *Phil. Trans.*

* Shistus (Argillaceous). Clay-slate.*

* Siberite. Red tourmaline.*

* Sidero-calcite. Brown spar.*

* Siderum. Bergmann's name for phosphuret of iron.*

* Sienite *or* Syenite. A compound granular aggregated rock, composed of feldspar and hornblende, and sometimes quartz and black mica. The hornblende is the characteristic ingredient, and distinguishes it perfectly from granite, with which it is often confounded; but the feldspar, which is almost always red, and seldom inclines to green, forms the most abundant and essential ingredient of the rock. Some varieties contain a very considerable portion of quartz and mica, but little hornblende. This is particularly the case with the Egyptian varieties, and hence these are often confounded with real granite.

As it has many points of agreement with greenstone, it is necessary to compare them together. In greenstone, the hornblende is usually the predominating ingredient; in sienite, on the contrary, it is the feldspar that predominates. In greenstone, the feldspar is almost always green, or greenish; here, on the contrary, it is as constantly red, or reddish. Quartz and mica are very rare in greenstone, and in inconsiderable quantity; whereas they are rather frequent in sienite. *Lastly*, greenstone commonly contains iron pyrites, which never occurs in sienite.

It has either a simple granular base, or it is granular porphyritic; and then it is denominated porphyritic sienite. When the parts of the granular base are so minute as to be distinguished with difficulty, and it contains imbedded in it large crystals of feldspar, the rock is termed sienite-porphyry. It is sometimes unstratified, sometimes very distinctly stratified. It sometimes shows a tendency to the columnar structure. It contains no foreign beds. It occurs in unconformable and overlying stratification, over granite, gneiss, mica-slate, and clay-slate, and is pretty continuous, and covers most of the primitive rocks. It is equally metalliferous with porphyry. In the Island of Cyprus, it affords much copper; many of the important silver and gold mines in Hungary are situated in it. The sienite of the Forest of Thuringia affords iron. In this country, there is a fine example of sienite, in Galloway, where it forms a considerable portion of the hill called Criffle. On the Continent, it occurs in the Electorate of Saxony; and in Upper Egypt, at the city of Syena, in Thebaid, at the cataracts of the Nile, whence it derives its name. The Romans brought it from that place to Rome, for architectural and statuary purposes.—*Jameson.**

* Silica. One of the primitive earths, which in consequence of Sir H. Davy's researches on the metallic bases of the alkalis and earths, has been recently regarded as a compound of a peculiar combustible principle with oxygen. If we ignite powdered quartz with three parts of pure potash in a silver crucible, dissolve the fused compound in water, add to the solution a quantity of acid, equivalent to saturate the alkali, and evaporate to dryness, we shall obtain a fine gritty powder, which being well washed with hot water, and ignited, will leave pure silica. By passing the vapour of potassium over silica in an ignited tube, Sir H. Davy obtained a dark-coloured powder, which apparently contained silicon, or silicium, the basis of the earth. Like boron and carbon, it is capable of sustaining a high temperature without suffering any change. Aqueous potash seems to form with it an olive-coloured solution. But as this basis is decomposed by water, it was not possible to wash away the potash by this liquid. Berzelius and Stromeyer tried to form an alloy of silicon or silicium with iron, by exposing to the strongest heat of a blast furnace, a mixture of three parts of iron, 1.5 silica, and 0.66 charcoal. It was in the state of fused globules. These, freed from the charcoal, were white and ductile, and their solution in muriatic acid evolved more hydrogen than an equal weight of iron. The sp. gravity of the alloy was from 6.7 to 7.3, while that of the iron used was 7.8285. From Mr. Mushet's experiments, however, as well as from the constitution of plumbago, we know that carbon will combine with iron in very considerable proportions, and that in certain quantities, it can give it a whitish colour and inferior density. Nothing definitive therefore can be inferred from these experiments. See iron.

Sir H. Davy found, that more than three parts of potassium were required to decompose one part of silica. Hence we might infer, that 100 parts of silica contain about 60 of oxygen. In this case, the prime equivalent of silicon, or silicium, would be 1.5, and that of silica 2.5; but little confidence can at present be reposed in such deductions.

"When iron," says Sir H. Davy, "is negatively electrified, and fused by the voltaic battery in contact with hydrate of silica, the metalline globule procured contains a matter which affords silex during its solution; and when potassium is brought in contact with silica ignited to whiteness, a compound is formed, consisting of silica and potassa; and black particles, not unlike plumbago, are found diffused through the compound. From some experiments I made, I am inclined to believe, that these particles are conductors of electricity; they have little action upon water, unless it contain acid, when they slowly dissolve in it with effervescence; they burn when strongly heated, and become converted into a white substance, having the characters of silica; so that there can be little doubt, both from analysis and synthesis, of the nature of silica." *Elements*, p. 363.

I have already mentioned in treating of earths, that Mr. Smithson had ingeniously suggested, that silica might be viewed in many mineral compounds as acting the part of an acid. This however is a vague analogy, and cannot justify us in ranking silica with acid bodies.

When obtained by the process first described; it is a white powder, whose finest particles have a harsh and gritty feel. Its sp. gr. is 2.66. It is fusible only by the hydroxygen blow-pipe. The saline menstruum, formed by neutralizing its alkaline solution with an acid, is capable of holding it dissolved, though silica seems by experiment to be insoluble in water. Yet in the water of the Geyser spring, a portion of silica seems to remain dissolved, though the quantity of alkali present appears inadequate to the effect. Silica exists nearly pure in transparent quartz or rock crystal. It forms also the chief constituent of flints. By leaving a solution of silica in fluoric acid, or in aqueous potash, undisturbed for a long time, crystals of this earth have been obtained. The solution in alkaline lixivia is called *liquor silicum*. Glass is a compound of a similar nature, in which the proportion of silica is much greater.

Mr. Kirwan made many experiments on the mutual actions of silica and the other earths, at high degrees of heat. The following are some of his results:

Proportions.	*Heat.*	*Effects.*
80 silica, 20 barytes,	150° Wedg.	A white brittle mass.
75 silica, 25 barytes,	150	A brittle hard mass, semi-transparent at the edges.
66 silica, 33 barytes,	150	Melted into a hard somewhat porous porcelain.
50 silica, 50 barytes,	148	A hard mass, not melted.
20 silica, 80 barytes,	148	The edges were melted into a pale greenish matter, between a porcelain and enamel.
25 silica, 75 barytes,	150	Melted into a somewhat porous porcelain mass.
33 silica, 66 barytes,	150	Melted into a yellowish and partly greenish white porous porcelain.

When the barytes exceeds the silica in the proportion of three to one, the fused mass is soluble in acids,—a circumstance recently applied with great advantage in the analysis of minerals which contain alkaline matter.

The habitudes of strontian with silica are nearly the same as those of barytes. Lime-water added to the *liquor silicum*, occasions a precipitate, which is a compound of the two earths. The following are Mr. Kirwan's results in the dry way:—

Proportions.	*Heat.*	*Effects.*
50 lime, 50 silica,	150° Wedg.	Melted into a mass of a white colour, semi-transparent at the edges, and striking fire, though feebly, with steel: it was intermediate between porcelain and enamel.
80 lime, 20 silica,	156	A yellowish-white loose powder.
20 lime, 80 silica,	156	Not melted: formed a brittle mass.

When exposed to the highest possible heat, magnesia and silica, in equal parts, melt into a white enamel.

Silica and alumina unite both in the liquid and dry way. The latter compound constitutes porcelain and pottery-ware.

Equal parts of lime, magnesia, and silica, melt, according to Achard, into a green ish-coloured glass, hard enough to strike fire with steel. When the magnesia exceeds either of the other two ingredients, the mixture is infusible; when the silica exceeds, the only fusible proportions were, 3 silica, 2 lime, 1 magnesia; and when the lime is in excess, the mixture usually melts in a strong heat. With mixtures of lime, alumina, and silica, a fusible compound is usually obtained when the lime predominates. The only refractory proportions were,

Lime,	2	3
Silica,	1	1
Alumina,	2	2

Excess of silica gives a glass or porcelain, but excess of alumina will not furnish a glass.

When in mixtures of magnesia, silica, and alumina, the first is in excess, no fusion takes place at 150°; when the second exceeds, a porcelain may be formed, and 3 parts of silica, 2 magnesia, and 1 alumina, form a glass. From Achard's experiments it would appear, that a glass may be produced by exposing to a strong heat, equal parts of alumina, silica, lime, and magnesia.

Other proportions gave fusible mixtures, provided the silica was in excess.

The mineral sommite, or nephelin, consists, according to Vauquelin, of 49 alumina + 46 silica. If we suppose it to consist of a prime equivalent or atom of each constituent, then that of silica would be 3; for 49 : 3.2 :: 46 : 3. But if we take Vauquelin's analysis of euclase for the same purpose, we have the proportion of silica to that of alumina as 35 to 22. Hence, 22 : 3.2 :: 35 : 5.09, the prime equivalent of silica, which is not reconcileable to the above number, though it agrees with that deduced from Sir H. Davy's experiments on silicon. I give these examples to show how unprofitable such atomical determinations are. See Iron, and Acid (Fluosilicic).*

Silk. See Bleaching.

Silvan. Tellurium; so called by Werner.

Silver is the whitest of all metals, considerably harder than gold, very ductile and malleable, but less malleable than gold; for the continuity of its parts begins to break when it is hammered out into leaves of about the hundred and sixty thousandth of an inch thick, which is more than one-third thicker than gold leaf; in this state it does not transmit the light. Its specific gravity is from 10.4 to 10.5. It ignites before melting, and requires a strong heat to fuse it. The heat of common furnaces is insufficient to oxidize it; but the heat of the most powerful burning lenses vitrifies a portion of it, and causes it to emit fumes; which, when received on a plate of gold, are found to be silver in the metallic state. It has likewise been partly oxidized by twenty successive exposures to the heat of the porcelain furnace at Sevres. By passing a strong electric shock through a silver wire, it may be converted into a black oxide; and by a powerful galvanic battery, silver leaf may be made to burn with a beautiful green light. Lavoisier oxidized it by the blowpipe and oxygen gas; and a fine silver wire burns in the kindled united stream of oxygen and hydrogen gases. The air alters it very little, though it is disposed to obtain a thin purple or black coating from the sulphurous vapours, which are emitted from animal substances, drains, or putrefying matters. This coating, after a long series of years, has been observed to scale off from images of silver exposed in churches; and was found, on examination, to consist of silver united with sulphur.

* There seems to be only 1 oxide of silver, which is formed either by intense ignition in an open vessel, when an olive-coloured glass is obtained; or by adding a solution of caustic barytes to one of nitrate of silver, and heating the precipitate to dull redness. Sir H. Davy found that 100 of silver combine with 7.3 of oxygen in the above oxide; and if we suppose it to consist of a prime equivalent of each constituent, we shall have 13.7 for the prime of silver. Silver leaf burned by a voltaic battery, affords the same olive-coloured oxide.

Silver combines with chlorine, when the metal is heated in contact with the gas. This chloride is, however, usually prepared by adding muriatic acid or a muriate, to nitrate of silver. It has been long known by the name of *luna-cornea* or *horn-silver*, because though a white powder, as it falls down from the nitrate solution, it fuses at a moderate heat, and forms a horny looking substance when it cools. It consists of 13.7 silver + 4.5 chlorine.

The sulphuret of silver is a brittle substance, of a black colour and metallic lustre. It is formed by heating to redness thin plates of silver stratified with sulphur. It consists of 13.7 silver + 2 sulphur.

Fulminating silver is formed by pouring lime-water into the pure nitrate, and filtering, washing the precipitate, and then digesting on it liquid ammonia in a little open capsule. In 12 hours, the ammonia must be cautiously decanted from the black powder, which is to be dried in minute portions, and with extreme circumspection, on bits of filtering paper or card. If struck, in even its moist state, with a hard body, it explodes; and if in any quantity, when dry, the fulmination is tremendous. The decanted ammonia, on being gently heated, effervesces, from disengagement of azote, and small crystals appear in it when it cools. These possess a still more formidable power of detonation, and can scarcely bear touching, even under the liquid. It seems to be a compound either of oxide of silver and ammonia, or of the oxide and azote. The latter is probably its true constitution, like the explosive iodide and chloride. The sudden extrication of the condensed gas, is the cause of the detonation.

In the 8th number of the Journal of Science, Mr. Farraday has described some experiments which seem to show that there is a protoxide of silver containing about two-thirds the quantity of oxygen found in the common oxide, by precipitation from the nitrate. He procures it by leaving an ammoniacal solution of oxide of silver exposed to the air. A succession of brilliant pellicles is obtained, which are the protoxide. Experiments of this nature must be made cautiously, lest fulminating compounds should accidentally be produced.*

Silver is soluble in the sulphuric acid when concentrated and boiling, and the metal in a state of division.

The muriatic acid does not act upon it, but the nitric acid, if somewhat diluted, dissolves it with great rapidity, and with a plentiful disengagement of nitrous gas; which, during its extrication, gives a blue or green colour to the acid, that entirely disappears if the silver made use of be pure. If it contain copper, the solution remains greenish; and if the acid contain either sulphuric or muriatic acid, these combine with a portion of the silver, and form scarcely soluble compounds, which fall to the bottom. If the silver contain gold, this metal separates in blackish-coloured flocks.

The nitric acid dissolves more than half its weight of silver; and the solution is very caustic, that is to say, it destroys and corrodes animal substances very powerfully.

The solution of silver, when fully saturated, deposites thin crystals as it cools, and also by evaporation. These are called lunar nitre, or nitrate of silver. A gentle heat is sufficient to fuse them, and drive off their water of crystallization. In this situation, the nitrate, or rather sub-nitrate, for the heat drives off part of the acid, is of a black colour, may be cast into small sticks in a mould, and then forms the lapis infernalis, or lunar caustic used in surgery. A stronger heat decomposes nitrate of silver, the acid flying off, and the silver remaining pure. It is obvious that, for the purpose of forming the lunar caustic, it is not necessary to suffer the salt to crystallize, but that it may be made by evaporating the solution of silver at once to dryness; and as soon as the salt is fused, and ceases to boil, it may be poured out. The nitric acid driven off from nitrate of silver is decomposed, the products being oxygen and nitrogen.

The sulphate of silver, which is formed by pouring sulphuric acid into the nitric solution of silver, is sparingly soluble in water; and on this account forms crystals, which are so small, that they compose a white powder. The muriatic acid precipitates from nitric acid the saline compound called lunacornea, or horn-silver; which has been so distinguished, because, when melted and cooled, it forms a semi-transparent and partly flexible mass, resembling horn. It is supposed that a preparation of this kind has given rise to the accounts of malleable glass. This effect takes place with aqua regia, which acts strongly on silver, but precipitates it in the form of muriate, as fast as it is dissolved.

If any salt with base of alkali, containing the muriatic acid, be added to the nitric solution of silver, the same effect takes place by double affinity; the alkaline base uniting with the nitric acid, and the silver falling down in combination with the muriatic acid.

Since the muriatic acid throws down only silver, lead, and mercury, and the two latter of these are not present in silver that has passed cupellation, though a small quantity of copper may elude the scorification in that process, the silver which may be revived from its muriate is purer than can readily be obtained by any other means. When the salt is exposed to a low red heat, its acid is not expelled; and a greater heat causes the whole concrete either to rise in fumes, or to pass through the pores of the vessel. To reduce it, therefore, it is necessary that it should be triturated with its own weight of fixed alkali, and a little water, and the whole afterwards exposed to heat in a crucible, the bottom of which is covered with soda; the mass of muriate of silver being likewise covered with the same substance. In this way the acid will be separated from the silver, which is reduced to its metallic state.

As the precipitate of muriate of silver is very perceptible, the nitric solution of silver is used as a test of the presence of muriatic acid in waters; for a drop of the solution poured into such waters will cause a very evident cloudiness. The solution of silver is also used by assayers to purify the nitric acid from any admixture of muriatic acid. In this state they call it precipitated aquafortis.

M. Chenevix found, that a chlorate of silver may be formed, by passing a current of chlorine through water in which oxide of silver is suspended; or by digesting phosphate of silver with hyperoxymuriate of alumina. It requires only two parts of hot water for its solution, and this affords, on cooling, small white, opaque, rhomboidal crystals. It is likewise somewhat soluble in alcohol. Half a grain, mixedwith half as much sulphur, and struck or rubbed, detonates with a loud report and a vivid flash.

Compounds of silver with other acids are best formed by precipitation from its solution in nitric acid; either by the acid itself, or by its alkaline salts. Phosphate of silver is a dense white precipitate, insoluble in water, but soluble in an excess of its acid. By heat it fuses into a greenish opaque glass. Carbonate of silver is a white insoluble powder, which is blackened by light. The fluate and borate are equally insoluble. Distilled vinegar readily dissolves the oxide of silver, and the solution affords long white needles, easily crystallized.

The precipitates of silver, which are formed by the addition of alkalis or earths, are all reducible by mere heat, without the addition of any combustible substance.

A detonating powder has been sold lately at Paris as an object of amusement. It is enclosed between the folds of a card, cut in two lengthwise; the powder being placed at one end, and the other being notched, that it may be distinguished. If it be taken by the notched end, and the other be held over the flame of a candle, it soon detonates, with a sharp sound, and violent flame. The card is torn, and changed brown; and the part in contact with the composition is covered with a slight metallic coating, of a grayish-white colour.

This compound, which M. Descotills calls detonating silver, to distinguish it from the fulminating silver of M. Berthollet, may be made by dissolving silver in pure nitric acid, and pouring into the solution, while it is going on, a sufficient quantity of rectified alcohol: or by adding alcohol to a nitric solution of silver with considerable excess of acid.

In the first case, the nitric acid, into which the silver is put, must be heated gently, till the solution commences, that is, till the first bubbles begin to appear. It is then to be removed from the fire, and a sufficient quantity of alcohol to be added immediately, to prevent the evolution of any nitrous vapours. The mixture of the two liquors occasions an extrication of heat; the effervescence quickly recommences, without any nitrous gas being disengaged; and it gradually increases, emitting at the same time a strong smell of nitric ether. In a short time the liquor becomes turbid, and a very heavy, white, crystalline powder falls down, which must be separated, when it ceases to increase, and washed several times with small quantities of water.

If a very acid solution of silver previously made be employed, it must be heated gently, and the alcohol then added. The heat excited by the mixture, which is to be made gradually, soon occasions a considerable ebullition, and the powder immediately precipitates.

It would be superfluous to remind the chemist, that the mixture of alcohol with hot nitric acid is liable to occasion accidents, and that it is consequently prudent to operate on small quantities.

This powder has the following properties: It is white and crystalline; but the size and lustre of the crystals are variable. Light alters it a little. Heat, a blow, or long continued friction, causes it to inflame with a brisk detonation. Pressure alone, if it be not very powerful, has no effect on it. It likewise detonates by the electric spark. It is slightly soluble in water. It has a very strong metallic taste.

Concentrated sulphuric acid occasions it to take fire, and is thrown by it to a considerable distance. Dilute sulphuric acid appears to decompose it slowly.

Process for separating silver from copper, by Mr. Keir.

Put the pieces of plated metal into an earthen glazed pan; pour upon them some acid liquor, which may be in the proportion of eight or ten pounds of sulphuric acid to one pound of nitre; stir them about, that the surfaces may be frequently exposed to fresh liquor, and assist the action by a gentle heat from 100° to 200° of Fahrenheit's scale. When the liquor is nearly saturated, the silver is to be precipitated from it by common salt, which forms a muriate of silver, easily reducible by melting it in a crucible with a sufficient quantity of potash; and lastly, by refining the melted silver if necessary, with a little nitre thrown upon it. In this manner the silver will be obtained sufficiently pure, and the copper will remain unchanged. Otherwise, the silver may be precipitated in its metallic state, by adding to the solution of silver a few of the pieces of copper, and a sufficient quantity of water to enable the liquor to act upon the copper.

Mr. Andrew Thomson, of Banchory, has recommended the following method of purifying silver, which he observes is equally applicable to gold. The impure silver is to be flatted out to the thinness of a shilling, coiled up spirally, and put into a crucible, the bottom of which is covered with black oxide of manganese. More of this oxide is then to be added, till the silver is completely covered, and all the spaces between the coils filled. A cover is then to be luted on, with a small hole for the escape of the gas; and after it has been exposed to a heat sufficient to melt silver for about a quarter of an hour, the whole of the alloy will be oxidized. The contents of this crucible are then to be poured into a larger, into which about three times as much powdered green glass has been previously put; a cover luted on as before, to prevent the access of any inflammable matter; and the crucible exposed to a heat sufficiently strong to melt the glass very fluid. On cooling and breaking the crucible, the silver will be found reduced at the bottom, and perfectly pure.

† A piece of silver coin, being dissolved in nitric acid, and left upon a warm stove, crystals were found in the vessel on the next morning. These, when dissolved in pure water, formed a colourless solution, and gave no trace of copper on adding liquid ammonia. I infer, that crystallization may prove an eligible mode of procuring a pure nitrate, and of course lunar caustic or pure silver.†

Sulphur combines very easily with silver, if thin plates, imbedded in it, be exposed to a heat sufficient to melt the sulphur. The sulphuret is of a deep violet colour, approaching to black, with a degree of metallic lustre, opaque, brittle, and soft. It is more fusible than silver, and this in proportion to the quantity of sulphur combined with it. A strong heat expels part of the sulphur.

Sulphuretted hydrogen soon tarnishes the surface of polished silver, and forms on it a thin layer of sulphuret.

The alkaline sulphurets combine with it by heat, and form a compound soluble in water. Acids precipitate sulphuret of silver from this solution.

Phosphorus, left in a nitric solution of silver, becomes covered with the metal in a dendritic form. By boiling, this becomes first white, then a light black mass, and is ultimately converted into a light brown phosphuret. The best method of forming a phosphuret of silver is Pelletier's, which consists in mixing phosphoric acid and charcoal with the metal, and exposing the mixture to heat.

Most metallic substances precipitate silver in the metallic state from its solution. The assayers make use of copper to separate the silver from the nitric acid used in the process of parting. The precipitate of silver by mercury is very slow, and produces a peculiar symmetrical arrangement, called the tree of Diana. In this, as in all precipitations, the peculiar form may be affected by a variety of concomitant circumstances; for which reason one process usually succeeds better than another.

Make an amalgam, without heat, of four drachms of leaf silver with two drachms of mercury. Dissolve the amalgam in four ounces, or a sufficient quantity of pure nitric acid of a moderate strength; dilute this solution in about a pound and a half of distilled water; agitate the mixture, and preserve it for use in a glass bottle with a ground stopper. When this preparation is to be used, the quantity of one ounce is put into a phial, and the size of a pea of amalgam of gold, or silver, as soft as butter, is to be added; after which the vessel must be left at rest. Soon afterwards small filaments appear to issue out of the ball of amalgam, which quickly increase, and shoot out branches in the form of shrubs.

Silver unites with gold by fusion, and forms a pale alloy, as has been already mentioned in treating of that metal. With platina it forms a hard mixture, rather yellower than silver itself, and of difficult fusion. The two metals do not unite well. Silver melted with one-tenth part of crude platina, from which the ferruginous particles had been separated by a strong magnet, could not be rendered clear of scabrous parts, though it was repeatedly fused, poured out, and laminated between rollers. It was then fused, and suffered to cool in the crucible, but with no better success. After it had been formed, by rolling and hammering, into a spoon for blow-pipe experiments, it was exposed to a low red heat, and became rough, and blistered over its whole surface. The quantities were one hundred grains of silver, and ten grains of platina. Nitre was added during the fusions.

Silver very readily combines with mercury. A very sensible degree of heat is produced, when silver leaf and mercury are kneaded together in the palm of the hand. With lead it forms a soft mass, less sonorous than pure silver. With copper it becomes harder and more sonorous, at the same time that it remains sufficiently ductile: this mixture is used in the British coinage. 12½ parts of silver, alloyed with one of copper, form the compound called standard silver. The mixture of silver and iron has been little examined. With tin it forms a compound, which, like that of gold with the same metal, has been said to be brittle, however small the proportion; though there is probably as little foundation for the assertion in the one case as in the other. With bismuth, arsenic, zinc, and antimony, it forms brittle compounds. It does not unite with nickel. The compound of silver and tungsten, in the proportion of two of the former to one of the latter, was extended under the hammer during a few strokes; but afterwards split in pieces. See Iron.

The uses of silver are well known: it is chiefly applied to the forming of various utensils for domestic use, and as the medium of exchange in money. Its disposition to assume a black colour by tarnishing, and its softness, appear to be the chief objection to its use in the construction of graduated instruments for astronomical and other purposes, in which a good white metal would be a desirable acquisition. The nitrate of silver, besides its great use as a caustic, has been employed as a medicine, it is said with good success, in epileptic cases, in the dose of 1-20th of a grain, gradually increased to 1-8th, three times a-day. Dr. Cappe gave it in a dose of 1-4th of a grain three times a-day, and afterward four times, in what he supposed to be a case of angina pectoris, in a stout man of sixty, whom he cured. He took it for three or four months. Dr. Cappe imagines, that it has the effect of increasing the nervous power, by which muscular action is excited.

* The frequent employment in chemical researches of nitrate of silver as a reagent for combined chlorine, occasions the production of a considerable quantity of the chloride (muriate) of silver, which is usually reconverted into metal by fusion with potash in a crucible. But, as much of the silver is lost in this way, it is better to expose the following mixture to the requisite heat:

Chloride of silver,	100
Dry quicklime,	19.8
Powdered charcoal,	4.2

An easier method, however, is to put the metallic chloride into a pot of clean iron or zinc, to cover it with a small quantity of water, and to add a little sulphuric or muriatic acid. The reduction of the chloride of silver by the zinc or iron, is an operation which it is curious to observe, especially with the chloride in mass (*luna cornea*). It begins first at the points of contact, and speedily extends in the form of ramifications, over its whole surface, and into its interior. Hence, in less than an hour, considerable pieces of horn silver are entirely reduced. If the mass operated on be considerable, the temperature rises, and accelerates the revivification. On the small scale artificial heat may be applied.*—*Ann. de Chimie, July* 1820.

Silvering. There are various methods of giving a covering of silver or silvery aspect to the surfaces of bodies. The application of silver leaf is made in the same way as that of gold, for which see Gilding.

Copper may be silvered over by rubbing it with the following powder: Two drachms of tartar, the same quantity of common salt, and half a drachm of alum, are mixed with fifteen or twenty grains of silver precipitated from nitric acid by copper. The surface of the copper becomes white when rubbed with this powder, which may afterward be brushed off and polished with leather.

The saddlers and harness-makers cover their wares with tin for ordinary uses; but a cheap silvering is used for this purpose as follows: Half an ounce of silver that has been precipitated from aquafortis by the addition of copper, common salt, and muriate of ammonia, of each two ounces, and one drachm of corrosive muriate of mercury, are triturated together, and made into a paste with water; with this, copper utensils of every kind, that have been previously boiled with tartar and alum, are rubbed, after which they are made red-hot, and then polished. The intention of this process appears to be little more than to apply the silver in a state of minute division to the clean surface of the copper, and afterward to fix it there by fusion; and accordingly this silvering may be effected by using the argentine precipitate here mentioned, with borax or mercury, and causing it to adhere by fusion.

The dial-plates of clocks, the scales of barometers, and other similar articles are silvered by rubbing upon them a mixture of muriate of silver, sea salt, and tartar, and afterward carefully washing off the saline matter with water. In this operation, the silver is precipitated from the muriatic acid, which unites with part of the coppery surface. It is not durable, but may be improved by heating the article, and repeating the operation till the covering seems sufficiently thick.

The silvering of pins is effected by boiling them with tin filings and tartar.

Hollow mirrors or globes are silvered by an amalgam consisting of one part by weight of bismuth, half a part of lead, the same quantity of pure tin, and two parts mercury. The solid metals are to be first fused together, and the mercury added when the mixture is almost cold. A very gentle heat is sufficient to fuse this amalgam. In this state it is poured into a clean glass globe intended to be silvered, by means of a paper funnel which reaches to the bottom. At a certain temperature it will stick to the glass, which by a proper motion may thus be silvered completely, and the superfluous amalgam poured out. The appearance of these toys is varied by using glass of different colours, such as yellow, blue, or green.

* Skorodite. Colour leek-green. Massive, but generally crystallized in very short broad rectangular four-sided prisms. Fracture uneven. Translucent. As hard as calcareous spar. Easily frangible. It melts before the blow-pipe, with emission of arsenical vapour, and is converted into a reddish-brown mass, which, when highly heated, so as to drive off all the arsenic, becomes attracted by the magnet. It is an arseniate of iron, without copper. It occurs in quartz and hornstone, in primitive rocks, in the Schneeberg mining district in Saxony.*

* Slate (Adhesive). See Clay.*

* Slate Clay. See Clay.*

* Slate Coal. See Coal.*

* Slate Spar, or Schiefer Spar. A sub-species of limestone.*

* Slickensides. The specular variety of Galena, so called in Derbyshire. It expresses the smoothness of its surface. It occurs lining the walls of very narrow rents. It has a most remarkable property, that when the rock in which it is contained is struck with a hammer, a crackling noise is heard, which is generally followed by an explosion of the rock, in the direction and neighbourhood of the vein. The cause of this singular effect has not been satisfactorily explained.—*Jameson.**

Smalt. See Zaffre.

* Smaragdite. Diallage.*

Smaragdus. See Emerald.

Soap. Macquer gives us the following process for oil soap: One part of quicklime and two parts of good Spanish soda, are boiled together during a short time, with twelve times as much water, in an iron caldron. This lixivium is to be filtered, and evaporated by heat, till a phial, which is capable of containing an ounce of water, shall contain an ounce and three-eighths of this concentrated lixivium. One part of this lixivium is to be mixed with two parts of oil of olives, or of sweet almonds, in a glass or stoneware vessel. The mixture is to be stirred from time to time with an iron spatula, or with a pestle, and it soon becomes thick and white. The combination is gradually completed, and in seven or eight days a very white and firm soap is obtained.

For the coarser sorts of soap, cheaper oils are employed, such as oil of nuts, linseed, hempseed, fish, &c. Either of these kinds of soap, to be good, must neither feel greasy nor unctuous in water, nor exhibit any vestige of fat upon the water. It ought farther to dissolve easily in water, and lather well, as likewise be easily soluble in alcohol. It must not become moist in the air, or throw out a saline efflorescence on its external surface.

For making Brown or Yellow Soap.

Let there be weighed 10 cwt. of tallow, and about 3 cwt. of resin, the resin to be broken into small lumps. In the first place, put into the boiler about 150 or 200 gallons of ley, and set the fire; then add the tallow and resin. This done, the pan is said to be charged.

A good fire may be kept up until all is thoroughly melted, and the pan brought to boil; during which time there ought to be constant stirring with the paddle, to prevent the resin from settling to the bottom. If the goods or materials in the pan appear to swell up, damp the fire, which is done by opening the furnace door, and throwing ashes thereon, (some have proper dampers), when the whole will boil at leisure. As the caustic alkali immediately unites to the tallow, there is no occasion for long boiling; about two or three hours will be long enough. The fire may then be drawn, and the pan allowed to stand for four or six hours, when the weak ley may be pumped off, and fresh added for a second boil. It may be necessary to mention, that when the pan is wished to be cranned, or pumped off sooner, a few pails of cold ley must be thrown in, a little after the fire is drawn.

Set the fire again for the second boil, and when properly a-boil, two or three hours may be sufficient at any one time to continue the boil. The strength of the ley is often gone before this period arrives. A short experience, however, with attention, will perfectly inform any sagacious person with regard to this particular.

The boilings to be thus continued day after day, until the soap becomes thick, and of a strong consistence. Take then a little upon the forefinger, and after letting it cool a few seconds, press it with the thumb. If it squeeze into a thin hard scale, the soap is fit or ready for finishing: if otherwise it appear greasy, and stick to the finger, and of a soft consistence, more ley must be added; and if this does not harden it, another boil must be given. But, in consequence of the former scaly appearance, give the pan a good hearty boil, and draw the fire. Cool down with two or three pails of ley, and in about two hours thereafter pump off the ley; which should be done at all times as clean as possible. This done, put in six or eight pails of water to the boiler, (no ley at finishing being used), set a brisk fire, and keep constantly stirring with hand-stirrer and paddle alternately, until all is melted, and begins to show an appearance something like thin honey. Take now a little from a boiling part upon the hand-board, and observe, when held up, if any ley runs clearly from it. If it do, more water must be put in, and the boil continued. When, upon the other hand, no ley runs from the soap when held up slantingways upon the board, in this case too much water has already been given. A little strong solution of salt must now be added to open it, technically termed *cutting up;* or, instead of salt brine, a little strong common salt and water; about half a pailful may do. We come now to the most critical part of boiling, that is, the finishing of the soap: and it ought to be particularly attended to, that the soap be brought to such a state, as, when held up upon the hand-board, the ley does not *run* down from the soap, but is seen, as it were, just *starting* from it. The fire may then be drawn away, and the soap declared finished; or if palm-oil be wished for making it of a beautiful colour, about 20lbs. may be put into the boiler, after you discover, as above, the soap to be finished; and in about half an hour after the oil is put in, the fire may be drawn, and the whole allowed to stand for forty-eight hours, when it may be cast into the frames.

In about three days, (supposing the frames 30 inches deep), the whole will cut up into bars.

A Charge for pure White Soap.

The boiler being made perfectly clean, put in 10 cwt. of best home melted tallow, (no resin is used in white soap), with 200 gallons of ley; melt down with a moderate fire, as the goods now in hand are something similar to milk, exceeding apt to boil over.

Close attention, therefore, is absolutely needful upon this first boil; which may be continued about two hours, with a moderate fire, when it may be drawn away, and the pan allowed to settle about two hours, when the ley may be drawn off. The process to be observed in this soap is exactly similar to the last operation. Two or three boils a day to white soap may be given with great ease; the ley sooner subsiding in the boiler than with yellow soap, and can be cleaner pumped off.

When sufficient boils have been given, and the soap is arrived at perfection, it will assume an appearance something like a curdy mass. Take then a little upon your fore-finger, (as before directed), and if the same effect seem to attend it, that is, when pressed with the thumb it squeeze into a thin, hard, clear scale, and part freely from the finger, the soap is ready for finishing. Draw the fire, cool down with a few pails of ley, and in a short time thereafter pump clean off.

Set the fire, and add to the soap eight or ten pails of water, (the pail I suppose to contain about nine or ten English gallons). When this is melted, and properly incorporated with the soap, try, as formerly directed, if the ley run from it when held up upon the hand-board. If it do, more water must be put in. If it do not run, or there be no appearance of it, continue boiling for a short while longer, and then add a pail of salt and water pretty strong, mixed together; about one-third salt, and two-thirds water. This will have the effect of cutting up the pan, or separating the soap and water completely from one another. When this is apparent, draw the fire; let it stand for half an hour, when the water will pump off, bringing therewith most of the remaining alkaline ley of the former boil.

This I call the first washing; and if kelp ley has been used in the operation, the propriety of this must be conspicuous; for the water pumped off will be of an exceeding dark bottle-green colour. The finishing of white soap without this precaution, is the sole cause of the blueness, so frequently observed in this article when made and brought to market.

The blue ley being pumped clean off, set again the fire, and put into the boiler six or eight pails of water; and when thoroughly incorporated and boiled some time, try if the water run from the soap. If it do, add water in small quantities at a time, until it is observed not to run, but, as formerly mentioned for yellow soap, to appear as just starting from the soap. In this case after giving a good boil, and swelling the soap up in the pan to near the brim, draw away all the fire, and spread it about to die away. The pan is now finished, and may stand about twelve or fourteen hours; and if the quantity be large, that is, two, three, or four ton, double this time to stand will be much in favour of the soap, providing always, that it can be kept very close and warm in the boiler. If any blueness still appear, repeat the washing.

Before casting, I would recommend the frames to have a bottom and lining of coarse cloth, for white soap only. After all is cast into the frames, let it be well stirred, or crutched; and it is very proper, that it also be covered close up with old sheets, bass matts, &c. upon the top of the frame and soap, and allowed to cool gradually, and all together.

In about three or four days, (supposing, as formerly, the dip 30 inches), the coverings and frames may be taken off, and the whole cut up into such size of bars as may best suit the customers.

To give this white soap the perfume of what is commonly called Windsor soap, a little of the essential oil of caraway seeds, mixed with a small portion of alcohol, may be incorporated with the soap when putting into the frame, stirring it in by little at a time, so as to diffuse it throughout the whole mass.

For making Black or Green Soft Soap.

The peculiar method pursued in making this soap, differs considerably from that of making hard soap. The hard has the whole of the ley totally extracted before finishing: soft soap, on the contrary, retains the whole of the ley used in the making; becoming, with the other materials employed, one compound body, called *soft soap*. A few examples will clearly explain the nature and practical means made use of in producing this very useful soap.

We shall now commence an operation with a charge for what is called

First Crown Soft Soap, 18 *Barrels.*

The quantity of ley requisite for completion of this charge will be about 400 gallons; about one-third of which must be put into the boiler previous to any of the other materials: afterward add, 2 cwt. 2 qrs. of tallow, 2 cwt. 2 qrs. of hogs'-lard, and 70 gallons of olive oil. The ley herein to be used is supposed to be from Hungarian and English (Essex) ashes. The proportion is one of the English to eight of the Hungarian. The particular mode of proceeding is this: After the ley is put in, add the tallow, and light the fire. When all the tallow is melted, put in the oil, and draw the fire a little afterward, and allow the pan to stand about two hours. Light again the fire, and add about 20 gallons more of the ley. After the pan begins to boil, add now and then a little more ley, for the purpose of preventing the soap from boiling over; and this adding of ley is to be continued, until the soap is supposed to be about half boiled, when it will be time to try whether the soap has got too much or too little ley.

This trial is called *proving*, and is necessary to be done several times during the operation, and previous to the finishing. The method of performing it is this: Provide a piece of glazed Dutch delft, and also a clear clean knife; with the knife take up a piece of the soap from the pan, and if it turn whitish thereon, and fall from it in short pieces upon the delft, it is then to be concluded that too much ley has been put in; to rectify which, a little more oil must be added. On the contrary, if the soap want ley, it will fall from the knife in long ropy pieces; in consequence of which add some more ley. When, however, it happens to be brought to perfection, neither wanting more ley nor oil, but just in a right state, it will then be observed, when taken upon the knife, to stand the proper colour, not ropy, nor too white, but transparent. The fire may now be drawn, the soap being properly finished, and ought immediately to be cast into the barrels, firkins, &c.

Remember always, after the second time the fire is lighted, to keep the soap boiling briskly, till the pan is nearly ready, when it ought to boil slow, until finishing, and ready to cast.

A Charge for Second Crown Soft Soap.

280 lbs. of tallow,
140 gallons of ley,
82 gallons of whale oil.

Put in 100 gallons of ley, with the tallow, and light the fire. When the tallow is melted, add the oil, and draw the fire. Let all stand for two hours. Again light the fire, and add 20 gallons of ley. With this the boiling is to be continued, until the soap is about half finished, when 10 gallons more of ley are to be added. During the remainder of the boiling, add, at different periods, the other 10 gallons of ley, which will completely finish the soap. See FAT.

For *eau de luce*, Wiegleb directs, that in two drachms of the strongest alcohol be dissolved from six to ten drops of rectified oil of amber, and afterward one scruple of white soap; to this mixture is then to be poured an ounce of pure ammonia, and the whole well shaken together.

SOAP-STONE. See STEATITE.

* SODA. Formerly called the *mineral alkali*, because under the name of *natron* it is found native in mineral seams or crusts. The impure commercial substance called *barilla* is the incinerated *salsola soda*. Kelp, the incinerated sea-weed, is a still coarser article, containing seldom above 2 or 3 per cent of real soda, while barilla occasionally contains 20. The crystallized carbonate of soda of commerce is procured from the decomposition of sulphate of soda, or muriate of soda. The former is effected by calcination with charcoal and chalk in a reverberatory furnace; the latter is accomplished by the addition of carbonate of potash. To procure pure soda, we must boil a solution of the pure carbonate with half its weight of quicklime, and after subsidence decant the clear ley, and evaporate in a clean iron or silver vessel, till the liquid flows quietly like oil. It must then be poured out on a polished iron plate. It concretes into a hard white cake, which is to be immediately broken in pieces, and put up, while still hot, in a phial, which must be well corked. If the carbonate of soda be somewhat impure, then, after the action of lime, and subsequent concentration of the ley, alcohol must be digested on it, which will dissolve only the caustic pure soda, and leave the heterogeneous salts. By distilling off the alcohol in a silver alembic, the alkali may then be obtained pure.

This white solid substance is, however, not absolute soda, but a hydrate, consisting of about 100 soda + 28 water; or of nearly 77 + 23, in 100. If a piece of this soda be exposed to the air, it softens and becomes pasty; but it never deliquesces into an oily looking liquid, as potash does. The soda in fact soon becomes drier, because by absorption of carbonic acid from the air it passes into an efflorescent carbonate. Soda is distinguishable from potash by sulphuric acid, which forms a very soluble salt with the former, and a sparingly soluble one with the latter; by muriate of platina and tartaric acid, which occasion precipitates with potash salts, but not with those of soda.

The basis of soda is a peculiar metal, called *sodium*, discovered by Sir H. Davy in 1807, a few days after he discovered potassium. It may be procured in exactly the same manner as potassium, by electrical or chemical decomposition of the pure hydrate. A rather higher degree of heat, and greater voltaic power, are required to decompose soda than potash. Sodium resembles potassium in many of its characters. It is as white as silver, possesses great lustre, and is a good conductor of electricity. It enters into fusion at about 200° Fahr., and rises in vapour at a strong red heat. Its sp. gr. is, according to MM. Gay-Lussac and Thenard, 0.972, at the temperature of 59° Fahr. In the cold, it exercises scarcely any action on dry air, or oxygen. But when heated strongly in oxygen or chlorine, it burns with great brilliancy. When thrown upon water, it effervesces violently, but does not inflame, swims on the surface, gradually diminishes with great agitation, and renders the water a solution of soda. It acts upon most substances in a manner similar to potassium, but with less energy. It tarnishes in the air, but more slowly; and, like potassium, it is best preserved under naphtha.

Sodium forms two distinct combinations with oxygen; one is pure soda, whose hydrate is above described; the other is the orange oxide of sodium, observed, like the preceding oxide, first by Sir H. Davy in 1807, but of which the true nature was pointed out in 1810, by MM. Gay-Lussac and Thenard.

Pure soda may be formed by burning sodium in a quantity of air, containing no more oxygen than is sufficient for its conversion into this alkali; *i. e.* the metal must be in excess; a strong degree of heat must be employed.

Pure soda is of a gray colour; it is a non-conductor of electricity, of a vitreous fracture, and requires a strong red heat for its fusion. When a little water is added to it, there is a violent action between the two bodies; the soda becomes white, crystalline in its appearance, and much more fusible and volatile. It is then the substance commonly called *pure* or *caustic soda*; but properly styled the *hydrate*.

The other oxide, or peroxide of sodium, may be formed by burning sodium in oxygen in excess. It is of a deep orange colour, very fusible, and a non-conductor of electricity. When acted on by water, it gives off oxygen, and the water becomes a solution of soda. It deflagrates when strongly heated with combustible bodies.

The proportions of oxygen in soda, and in the orange peroxide of sodium are easily learned by the action of sodium on water and on oxygen. If a given weight of sodium, in a little glass tube, be thrown by means of the finger under a graduated inverted jar, filled with water, the quantity of hydrogen evolved will indicate the quantity of oxygen combined with the metal to form soda; and when sodium is slowly burned in a tray of platina, (lined with dry common salt), in oxygen in great excess, from the quantity of oxygen absorbed the composition of the peroxide may be learned. From Sir H. Davy's experiments, compared with those of MM. Gay-Lussac and Thenard, it appears that the prime equivalent of sodium is 2.95, and that of dry soda, or protoxide of sodium, 3.95; while the orange oxide or deutoxide is 4.95. The numbers given by M. Thenard are, for the first, 100 metal + 33.995 oxygen; and for the second, 100 metal + 67.990 oxygen.

Another oxide is described containing less oxygen than soda; it is therefore a suboxide. When sodium is kept for some time in a small quantity of moist air, or when sodium in excess is heated with hydrate of soda, a dark grayish substance is formed, more inflammable than sodium, and which affords hydrogen by its action upon water.

Only one combination of sodium and chlorine is known. This is the important substance *common salt*. It may be formed directly by combustion, or by decomposing any compound of chlorine by sodium. Its properties are well known, and are already described under ACID (MURIATIC). It is a non-conductor of electricity, is fusible at a strong red heat, is volatile at a white heat, and crystallizes in cubes. Sodium has a much stronger attraction for chlorine than for oxy[illegible], and soda, or its hydrate, is decompos[illegible]y chlorine, oxygen being expelled from the first, and oxygen and water from the second.

Potassium has a stronger attraction for chlorine than sodium has; and one mode of procuring sodium easily, is by heating together to redness, common salt and potassium. This chloride of sodium, improperly called the muriate, consists of 4.5 chlorine + 2.95 sodium. There is no known action between sodium and hydrogen or azote.

Sodium combines readily with sulphur and with phosphorus, presenting similar phenomena to those presented by potassium. The sulphurets and phosphurets of sodium agree in their general properties with those of potassium, except that they are rather less inflammable. They form, by burning, acidulous compounds of sulphuric and phosphoric acid and soda.

Potassium and sodium combine with great facility, and form peculiar compounds, which differ in their properties, according to the proportions of the constituents. By a small quantity of sodium, potassium is rendered fluid at common temperatures, and its sp. gr. is considerably diminished. Eight parts of potassium, and one of sodium, form a compound that swims in naphtha, and that is fluid at the common temperature of the air. Three parts of sodium, and one of potassium, make a compound, fluid at common temperatures. A little potassium destroys the ductility of sodium, and renders it very brittle and soft. Since the prime of potassium is to that of sodium, as 4.95 to 2.95; it will require the former quantity of potassium, to eliminate the latter quantity of sodium from the chloride. The attractions of potassium, for all substances that have been examined, are stronger than those of sodium.

Soda is the basis of common salt, of plate and crown-glass, and of all hard soaps. *Elements of Chemical Phil.**

* **Sodalite.** Colour green. Massive and crystallized in rhomboidal dodecahedrons. Shining. Cleavage double. Fracture small conchoidal. Translucent. As hard as feldspar. Brittle. Sp. gr. 2.378. It is infusible; becoming only dark gray before the blow-pipe. Its constituents are, silica 38.5 or 36, alumina 27.48 or 32, lime 2.7 or 0, oxide of iron 1 or 0.25, soda 25.5 or 25, muriatic acid 3 or 6.75; volatile matter 2.10 or 0, loss 1.7 or 0.—*Thomson and Ekeberg*. It was discovered in West Greenland by Sir Charles Gieseke, in a bed in mica slate.*

* **Sodium.** See Soda.*

Soil. The soil or earth in which vegetables grow, varies considerably in its composition, or in the proportions of the different earths of which it consists; and some plants are found to thrive best in one kind of soil, others in another. Under *Analysis* the methods of analyzing soils, so as to ascertain their composition, will be found, as given by Sir H. Davy; and we shall here subjoin the rules he has laid down for their improvement, as connected with the principles of which they consist.

In cases where a barren soil is examined with a view to its improvement, it ought in all cases, if possible, to be compared with an extremely fertile soil in the same neighbourhood, and in a similar situation; the difference given by their analyses would indicate the methods of cultivation, and thus the plan of improvement would be founded upon accurate scientific principles.

If the fertile soil contained a large quantity of sand, in proportion to the barren soil, the process of melioration would depend simply upon a supply of this substance; and the method would be equally simple with regard to soils deficient in clay or calcareous matter.

In the application of clay, sand, loam, marl, or chalk to lands, there are no particular chemical principles to be observed; but when quicklime is used, great care must be taken, that it is not obtained from the magnesian limestone; for in this case, as has been shown by Mr. Tennant, it is exceedingly injurious to land. The magnesian limestone may be distinguished from the common limestone by its greater hardness, and by the length of time that it requires for its solution in acids; and it may be analyzed by the process for carbonate of lime and magnesia.

When the analytical comparison indicates an excess of vegetable matter as the cause of sterility, it may be destroyed by much pulverization and exposure to air, by paring and burning, or the agency of lately made quicklime. And the defect of animal and vegetable matter must be supplied by animal or vegetable manure.

The general indications of fertility and barrenness, as found by chemical experiments, must, necessarily differ in different climates, and under different circumstances. The power of soils to absord moisture, a principle essential to their productiveness, ought to be much greater in warm and dry countries, than in cold and moist ones; and the quantity of fine aluminous earth they contain should be larger. Soils likewise that are situate on declivities ought to be more absorbent than those in the same climate on plains or in valleys.

The productiveness of soils must likewise be influenced by the nature of the sub-soil, or the earthy or stony strata on which they rest; and this circumstance ought to be particularly attended to, in considering their chemical nature, and the system of improvement. Thus a sandy soil may owe its fertility to the power of the sub-soil to retain water; and an absorbent clayey soil may occasionally be prevented from being barren, in a moist climate, by the influence of a substratum of sand or gravel.

Those soils that are most productive of corn, contain always certain proportions of aluminous or calcareous earth in a finely divided state, and a certain quantity of vegetable or animal matter.

The quantity of calcareous earth is however very various, and in some cases exceedingly small. A very fertile corn soil from Ormiston in East Lothian afforded in a hundred parts only eleven parts of mild calcareous earth; the finely divided clay amounted to forty-five parts. It lost nine in decomposed animal and vegetable matter, and four in water, and exhibited indications of a small quantity of phosphate of lime.

This soil was of a very fine texture, and contained very few stones or vegetable fibres. It is not unlikely, that its fertility was in some measure connected with the phosphate; for this substance is found in wheat, oats, and barley, and may be a part of their food.

A soil from the low lands of Somersetshire, celebrated for producing excellent crops of wheat and beans without manure, I found to consist of one-ninth of sand, chiefly siliceous, and eight-ninths of calcareous marl tinged with iron, and containing about five parts in the hundred of vegetable matter. I could not detect in it any phosphate or sulphate of lime, so that its fertility must have depended principally upon its power of attracting principles of vegetable nourishment from water and the atmosphere.

Mr. Tillet, in some experiments made on the composition of soils at Paris, found, that a soil composed of three-eighths of clay, two-eighths of river sand, and three-eighths of the parings of limestone, was very proper for wheat.

In general, bulbous roots require a soil much more sandy, and less absorbent, than the grasses. A very good potato soil, from Varsel in Cornwall, afforded seven-eighths of siliceous sand; and its absorbent power was so small, that 100 parts lost only 2 by drying at 400° Fahrenheit.

Plants and trees, the roots of which are fibrous and hard, and capable of penetrating deep into the earth, will vegetate to advantage in almost all common soils that are moderately dry, and do not contain a very great excess of vegetable matter.

The soil taken from a field at Sheffield-place in Sussex, remarkable for producing flourishing oaks, was found to consist of 6 parts of sand, and 1 part of clay and finely divided matter. And 100 parts of the entire soil submitted to analysis, produced water 3, silex 54, alumina 28, carbonate of lime 3, oxide of iron 5, decomposing vegetable matter 4, loss 3.

From the great difference of the causes that influence the productiveness of lands, it is obvious, that in the present state of science, no certain system can be devised for their improvement, independent of experiment; but there are few cases, in which the labour of analytical trials will not be amply repaid by the certainty with which they denote the best methods of melioration; and this will particularly happen, when the defect of composition is found in the proportions of the primitive earths.

In supplying animal or vegetable manure, a temporary food only is provided for plants, which is in all cases exhausted by means of a certain number of crops; but when a soil is rendered of the best possible constitution and texture with regard to its earthy parts, its fertility may be considered as permanently established. It becomes capable of attracting a very large portion of vegetable nourishment from the atmosphere, and of producing its crops with comparatively little labour and expense.

SOLDERS, and SOLDERING. Solders consist merely of simple or mixed metals, by which alone metallic bodies can be firmly united with each other. In this respect it is a general rule, that the solder should always be easier of fusion than the metal intended to be soldered by it; next to this, care must also be taken, that the solder be as far as is possible of the same colour with the metal that is to be soldered.

For the simple solders, each of the metals may be used according to the nature of that which is to be soldered. For fine steel, copper, and brass work, gold and silver may be employed. In the large way, however, iron is soldered with copper, and copper and brass with tin.

The most usual solders are the compound, which are distinguished into two principal classes, viz. hard and soft solders. The hard solders are ductile, will bear hammering, and are commonly prepared of the same metal with that which is to be soldered, with the addition of some other, by which a greater degree of fusibility is obtained, though the addition is not always required to be itself easier of fusion. Under this head comes the harder solder for gold, which is prepared from gold and silver, or gold and copper, or gold, silver, and copper. The hard solder for silver is prepared from equal parts of silver and brass, but made easier of fusion by the admixture of a sixteenth part of zinc. The hard solder for brass is obtained from brass mixed with a sixth, or an eighth, or even one-half of zinc, which may also be used for the hard solder of copper. It is sold in the shops in a granulated form, under the name of spelter-solder.

The soft solders melt easily, but are partly brittle, and therefore cannot be hammered. Of this kind are the following mixtures: tin and lead in equal parts; of still easier fusion is that consisting of bismuth, tin, and lead, equal parts; 1 or 2 parts of bismuth, of tin and lead each 1 part.

In the operation of soldering, the surfaces of the metal intended to be joined must be made very clean, and applied to each other. It is usual to secure them by a ligature of iron wire, or other similar contrivance. The solder is laid upon the joint, together with sal ammoniac or borax, or common glass, according to the degree of heat intended. These additions defend the metal from oxidation. Glaziers use resin; and pitch is sometimes employed.

Tin-foil applied between the joints of fine brass work, first wetted with a strong solution of sal ammoniac, makes an excellent juncture, care being taken to avoid too much heat.

SOLIDS and SOLIDITY. See CALORIC, and CRYSTALLIZATION.

SOLUTION. See SALT, CRYSTALLIZATION, and ATTRACTION.

SOMMITE. NEPHELINE.

SORBATES. Compounds of sorbic, or malic acid, with the salifiable bases. See ACID (SORBIC).

SORY. The ancient name of sulphate of iron.

SPAR (FLUOR). See FLUOR.

SPAR (PONDEROUS). See HEAVY-SPAR.

SPARRY ANHYDRITE, or CUBE-SPAR.

A sub-species of prismatic gypsum. Colour white, passing into blue or red. Massive, in distinct concretions, and crystallized. The primitive figure is an oblique prism, in which the angles are 108° 8′ and 79° 56′. The secondary forms are, a rectangular four-sided prism, a broad six-sided prism, an eight-sided prism, and a broad rectangular four-sided prism, acuminated. Splendent, pearly. Cleavage threefold. Fragments cubical. Fracture conchoidal. Transparent. Refracts double. Scratches calcareous spar, but not fluor. Brittle. Sp. gr. 2.7 to 3.0. It does not exfoliate before the blow-pipe, and melt like gypsum, but becomes glazed over with a white friable enamel. Its constituents are, lime 41.75, sulphuric acid 55, muriate of soda 1.—*Klaproth.* It is sometimes met with in the gypsum of Nottinghamshire. It occurs in the salt mines of Halle, &c.*

* **Sparry Iron.** Carbonate of iron. Colour pale yellowish-gray. Massive, disseminated and crystallized. The primitive form is a rhomboid of 107°. The following are some of the secondary forms. The primitive, perfect, or truncated; a still flatter rhomboid; the spherical lenticular form; the saddle shaped lens, and the equiangular six-sided prism. Glistening or splendent, or pearly. Cleavage threefold. Fracture foliated, or splintery. Translucent on the edges. Streak white or yellowish-brown. Harder than calcareous spar. Easily frangible. Sp. gr. 3.6 to 3.9 It blackens and becomes magnetic before the blow-pipe, but does not melt; it effervesces with muriatic acid. Its constituents are, oxide of iron 57.5, carbonic acid 36, oxide of manganese 3.5, lime 1.25.—*Klaproth.* It occurs in veins in granite, gneiss, &c. associated with ores of lead, cobalt, silver, copper, &c. But the most extensive formations of this mineral are in limestone. It is found in small quantities in England, Scotland, and Ireland; in Saxony, Bohemia, &c.; and in large quantities in Fichtelgebirge; and at Schmalkalden in Hessia. It affords an iron well suited for conversion into steel.—*Jameson.**

* **Specific Gravity.** The density of the matter of which any body is composed, compared to the density of another body, assumed as the standard. This standard is pure distilled water, at the temperature of 60° F. To determine the specific gravity of a solid, we weigh it, first in air, and then in water. In the latter case it loses, of its weight, a quantity precisely equal to the weight of its own bulk of water; and hence, by comparing this weight with its total weight, we find its specific gravity. The rule therefore is, divide the total weight, by the *loss* of weight in water, the quotient is the specific gravity. If it be a liquid or a gas, we weigh it in a glass or other vessel of known capacity; and dividing that weight, by the weight of the same bulk of water, the quotient is, as before, the specific gravity. See Hydrometer, for another modification of the same rule.

To calculate the mean specific gravity of a compound from those of its components, is a problem of perpetual recurrence in chemistry. It is only by a comparison of the result of that calculation, with the specific gravity of the compound experimentally ascertained, that we can discover whether the combination has been accompanied with expansion or condensation of volume. As several respectable experimental chemists (see Alloy and Ammonia) seem deficient in the knowledge of chemical computation, I shall here insert a short abstract of a paper which I published on this subject in the 7th number of the Journal of Science.

"The specific gravity of one body is to that of another, as the weight of the first, divided by its volume, is to the weight of the second, divided by its volume; and the mean specific gravity of the two, is found, by dividing the sum of the weights by the sum of the volumes.

Let W, *w*, be the two weights; V, *v*, the two volumes; *P*, *p*, the two specific gravities; and M, the calculated mean specific gravity, Then

$M = \frac{W + w}{V + v}$; the formula by which I computed the second column of Table II.

$$\text{And } V + v = \frac{W}{P} + \frac{w}{p} = \frac{Wp + wP}{Pp}$$

Hence

$$\frac{W + w}{V + v} = \frac{W + w}{\frac{Wp + wP}{Pp}} = \frac{(W + w)Pp}{Pw + pW} = M$$

When the difference in density, between the two substances is considerable, as it is with sulphuric acid and water, the errors produced by assuming the arithmetical mean, for the true calculated mean, are excessive. If we take copper and tin, however, then the arithmetical mean, $\frac{8.89 + 7.29}{2}$ = 8.09, differs very little from 8.01, the accurate mean density.

By a similar error, I suppose, in calculating the mean density of liquid muriatic acid in its different stages of dilution, the celebrated Kirwan has long misled the chemical world. He asserted, that the mean specific gravity of the components, being also the experimental mean, there is no condensation of volume, as with other acid dilutions. And the illustrious Berthollet has even assigned a cause for this suppositious fact. I find, on the contrary, that 50 of acid, sp. grav. 1.1920 with 50 of water, give out heat, and have their volume diminished in the ratio of 100 to 99.28. The experimental specific grav. is 1.0954; that, by the exact rule, is only 1.0875.

The preceding formula may be presented, under a still more convenient form. P, p being the specific gravities of the two components, we have $P = \frac{W}{V}$ and $p = \frac{w}{v}$; whence $V = \frac{W}{P}$, $v = \frac{w}{p}$.

In the condition when $W = w = 1$, we have then

$V = \frac{1}{P}$, $v = \frac{1}{p}$, and, consequently, therefore

$$2\Delta = (P-p) \times \frac{\frac{1}{P} - \frac{1}{p}}{\frac{1}{P} + \frac{1}{p}} = \frac{(P-p)(p-P)}{P+p}$$

$$= -\frac{(P-p)^2}{P+p}$$

This value being constantly negative, proves that the true value of the sp. grav. of the mixture, represented by $\frac{W+w}{V+v}$, is always smaller than the false value, $\frac{1}{2}\left(\frac{W}{V} + \frac{w}{v}\right)$.

Example of the last formula,

Gold and silver, $\frac{19.3+10.5}{2} = 14.9 =$ false or arithmetical mean specific gravity. $\frac{(P-p)^2}{P+p} = \frac{(19.3-10.5)^2}{29.8} = \frac{(8.8)^2}{29.8} = \frac{77.44}{29.8}$ $= 2.6 = 2\Delta$; and $\Delta = 1.3$, which being subtracted from the arithmetical mean 14.9, leaves 13.6 for the true mean specific gravity as directly obtained by the formula $\frac{(W+w)\,Pp}{Pw+pW}$.

SULPHURIC ACID TABLE,

Showing the erroneous results of the common method. See Alloy.

Acid in 100.	*Arithm. mean density.*	*Experimental density.*	*Apparent volume.*	*Acid in* 100.	*Arithm. mean density.*	*Experimental density.*	*Apparent volume.*
100		1.8480	100	50	1.4240	1.3884	102.6
90	1.7632	1.8115	97.3	40	1.3392	1.2999	103.02
80	1.6784	1.7120	98.0	30	1.2544	1.2184	102.95
70	1.5936	1.5975	99.7	20	1.1696	1.1410	102.50
60	1.5088	1.4860	101.5	10	1.0848	1.0680	101.57

* Specular Iron Ore. See Ores of Iron.*

Speculum. Mr. Edwards affirms, that different kinds of copper require different doses of tin to produce the most perfect whiteness. If the dose of tin be too small, which is the fault most easily remedied, the composition will be yellowish; if it be too great, the composition will be of a gray-blue colour, and dull appearance. He casts the speculum in sand, with the face downwards; takes it out while red-hot, and places it in hot wood ashes to cool; without which precaution it would break in cooling.

Mr. Little recommends the following proportions;—32 parts of the best bar copper, 4 parts of the brass of pin-wire, 16½ of tin, and 1¼ of arsenic. Silver he rejects, as it has an extraordinary effect of softening the metal; and he found, that the compound was not susceptible of the highest polish, unless it was extremely brittle. He first melts the brass, and adds to it about an equal weight of tin. When this mixture is cold, he puts it into the copper, previously fused with black flux, adds next the remainder of the tin, and lastly the arsenic. This mixture he granulates, by pouring into cold water, as Mr. Edwards did, and fuses it a second time for casting.

* Spermaceti. See Fat.*

* Sphene. Prismatic titanium ore.*

* Sphoerulite. Colours brown and gray. In imbedded roundish balls and grains. Glimmering. Fracture even, splintery. Opaque. Scratches quartz with difficulty. Brittle. Sp. gr. 2.4 to 2.5. Nearly infusible. It occurs in pearlstone and pitchstone porphyries, in the vicinity of Glasshütte near Schemnitz; and in the pitchstone of Meissen.*

* Sphragide. See Lemnian Earth.*

* Spinel. A sub-species of octohedral corundum. Colour red. Occurs in grains, more frequently crystallized; in a perfect octohedron, which is the fundamental figure; in a tetrahedron, perfect or modified; a thick equiangular six-sided table; a very oblique four-sided table; a rhomboidal dodecahedron; a rectangular four-sided prism.

Splendent and vitreous. Cleavage fourfold. Fracture flat conchoidal. Translucent to transparent. Refracts single. Scratches topaz, but is scratched by sapphire. Brittle. Sp. gr. 3.5 to 3.8 Fusible with borax. Its constituents are, alumina 82.47, magnesia 8.78, chromic acid 6.18, loss 2.57.—*Vauquelin.* It is found in the gneiss district of Acker in Sudermannland, in a primitive limestone; in the kingdom of Pegu, and in Ceylon. It is used as a precious stone. When it weighs four carats (about sixteen grains), it is considered of equal value with a diamond of half the weight.—*Jameson.**

* **Spinellane.** Colour plum-blue. It occurs crystallized in rhomboids of 117° 23′, and 62° 37′: and in six-sided prisms, acuminated with three planes. It scratches glass. It is found on the shores of the lake of Laach, in a rock composed of glassy feldspar, quartz, hornblende, &c. It is said to be a variety of Haüyne.*

* **Spinthere.** Colour greenish-gray. In small oblique double four-sided pyramids. It does not scratch glass. It occurs in the department of Isere in France, incrusting calcareous spar crystals. It is believed to be a variety of sphene.*

Spirit of Mindererus. A solution of acetate of ammonia, made by adding concrete carbonate of ammonia to distilled vinegar till saturation takes place.

Spirit of Nitre. See Acid (Nitric).

* **Spirit, (Pyro-acetic).** Some dry acetates exposed to heat in a retort yield a quantity of a light volatile spirit, to which the above name is given. When the acetate is easily decomposed by the fire, it affords much acid and little spirit; and on the contrary it yields much spirit and little acid, when a strong heat is required for its decomposition. The acetates of nickel, copper, &c. are in the first condition; those of barytes, potash, soda, strontian, lime, manganese, and zinc, are in the second. The following table of M. Chenevix, exhibits the products of the distillation of various acetates.

Table of Pyro-Acetic Spirit.

		Acetate of Silver.	*Acetate of Nickel.*	*Acetate of Copper.*	*Acetate of Lead.*	*Peracetate of iron.*	*Acetate of Zinc.*	*Acetate of Manganese*
Loss by the fire,		0.36	0.61	0.64	0.37	0.49		0.555
Residuum	State of the base (*a*).	*metallic.*	*metallic.*	*metallic.*	*metallic.*	*bl. oxide.*	*wh. oxide.*	*br. oxide.*
	Resid. Carbon.	0,05	0.14	0.055	0.04	0.02	0.05	0.035
Liquid products	Sp. gr.	1.0656	1.0398	1.0556	0.9407	1.011	0.8452	0.8264
	Ratio of acid.	107.309	44.731	84.863	3.045	27.236	2.258	1.285
	Pyro. spir.	0	almost 0	0.17	0.555	0.24	0.695	0.94
Gaseous products	Carb. acid. (*b*)	8	35	10	20	18	16	20
	Carb. hydro.	12	60	34	8	34	28	32
	Total gas.	20	95	44	28	52	44	52

We see, that of all the acetates, that of silver gives the most concentrated and purest acetic acid, since it contains no pyro-acetic spirit.

This spirit is limpid and colourless. Its taste is at first acrid and burning, then cooling, and in some measure urinous. Its odour approaches that of peppermint mingled with bitter almonds. Its sp. grav. is 0.7864. It burns with a flame interiorly blue, but white on the outside. It boils at 138.2 F. and does not congeal at 5° Fahr. With water it combines in every proportion, as well as with alcohol, and most of the essential oils. It dissolves but a little of sulphur and phosphorus, but camphor in very large quantity.

Caustic potash has very little action on the pyro-acetic spirit. Sulphuric and nitric acids decompose it; but muriatic acid forms with this body a compound, which is not acid, and in which we can demonstrate the presence of the muriatic acid, only by igneous decomposition. Hence we perceive that pyro-acetic spirit is a peculiar substance, which resembles the ethers, alcohol, and volatile oils. To obtain it cheaply,

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(*a*) Almost all the metallic residuums are pyrophoric, or susceptible of inflaming by contact of air, after complete refrigeration; which M. Chenevix ascribes to the finely divided charcoal mixed with the metallic part.

(*b*) The quantities marked here, are expressed in volumes we may employ the acetate of lead of commerce. After having distilled this salt in an earthen retort, and collected the liquid products in a globe, communicating by a tube with a flask surrounded with ice, we saturate these products with a solution of potash or soda, and then separate the spirit by means of a second distillation, taking care to use a regulated heat. As it usually carries over with it a little water, it is proper to rectify it from dry muriate of lime. *Ann. de Chimie*, tom. 69.*

* **Spirit of Sal Ammoniac.** Water of Ammonia.*

Spirit (Volatile) of Sal Ammoniac. See **Ammonia.**

* **Spirit of Salt.** See acid (**Muriatic**).*

* **Spirit of Wine.** Alcohol.*

* **Spodumene.** Prismatic triphane spar. —*Mohs.* Colour between greenish-white and mountain-gray. Massive, disseminated and in large granular concretions. Glistening, pearly. Cleavage threefold. Fracture fine grained uneven. Translucent. As hard as feldspar. Most easily frangible. Sp. gr. 3.0 to 3.1. Before the blow-pipe, it first separates into small gold-yellow coloured folia; and if the heat is continued, they melt into a greenish-white coloured glass. Its constituents are, silica 64.4, alumina 24.4, lime 3, potash 5, oxide of iron 2.2.—*Vauquelin.* It was first discovered in the Island of Uton in Sudermannland, where it is associated with red feldspar and quartz. It has been lately found in the vicinity of Dublin, by Dr. Taylor. It contains the new alkali *lithia,* by some recent analyses.*

Sponge. A soft, light, very porous, and compressible substance, readily imbibing water, and distending thereby. It is found adhering to rocks, particularly in the Mediterranean Sea, about the islands of the Archipelago. It was formerly supposed to be a vegetable production, but is now classed among the zoophytes; and analyzed, it yields the same principles with animal substances in general.

Stalactites. These are found suspended from vaults, being formed by the oozing of water charged with calcareous particles, and gradually evaporating, leaving those particles behind.

Starch. This is a white, insipid, combustible substance, insoluble in cold water, but forming a jelly with boiling water. It exists chiefly in the white and brittle parts of vegetables, particularly in tuberose roots, and the seeds of the gramineous plants. It may be extracted by pounding these parts, and agitating them in cold water; when the parenchyma or fibrous parts, will first subside; and these being removed, a fine white powder, diffused through the water, will gradually subside, which is the starch. Or the pounded or grated substance, as the roots of arum, potatoes, acorns, or horse-chesnuts, for instance, may be put into a hair-sieve, and the starch washed through with cold water, leaving the grosser matters behind. Farinaceous seeds may be ground and treated in a similar manner. Oily seeds require to have the oil expressed from them before the farina is extracted.

If starch be subjected to distillation, it gives out water impregnated with empyreumatic acetous acid; a little red or brown oil, a great deal of carbonic acid, and carburetted hydrogen gas. Its coal is bulky, easily burned, and leaves a very small quantity of potash and phosphate of lime. If when diffused in water, it be exposed to a heat of 60° F. or upward, it will ferment, and turn sour; but much more so if it be not freed from the gluten, extract, and colouring matter. Thus, in starch-making, the farina ferments and becomes sour, but the starch that does not undergo fermentation is rendered the more pure by this process. Some water already soured is mixed with the flour and water, which regulates the fermentation, and prevents the mixture from becoming putrid; and in this state it is left about ten days in summer and fifteen in winter, before the scum is removed, and the water poured off. The starch is then washed out from the bran, and dried, first in the open air, and finally in an oven.

With boiling water starch forms a nearly transparent mucilage, emitting a peculiar smell, neither disagreeable nor very powerful. This mucilage may be dried, and will then be semi-transparent, and much resembling gum, all the products of which it affords. When dissolved it is much more easily digested and nutritious than before it has undergone this operation.

Both acids and alkalies combined with water dissolve it. It separates the oxides of several metals from their solutions, and takes oxygen from many of them. It is found naturally combined with all the immediate principles of vegetables, and may easily be united with most of them by art.

* **Staurolite.** Grenatite, or prismatic garnet.*

* **Staurotide.** Grenatite, prismatic garnet, or staurolite. Colour dark reddish-brown. Only crystallized in forms which may be reduced to a prism of 129° 30′. The following are secondary forms: a very oblique four-sided prism, truncated on the acuter lateral edges, forming an unequiangular six-sided prism; the same acutely bevelled on the extremities; and a twin crystal, formed by two perfect six-sided prisms. Splendent, resino-vitreous. Cleavage in the smaller diagonal. Fracture, small grained uneven. Opaque or translucent. Scratches quartz feebly. Brittle. Sp. gr,

3.3 to 3.8. Infusible. Its constituents are, alumina 44, silica 33, lime 3.84, oxide of iron 13, oxide of manganese 1, loss 5.16.—*Vauquelin*. The geognostic relations of this mineral are nearly the same with those of precious garnet. It occurs in clay-slate near Ardonald, between Keith and Huntly, in Aberdeenshire, and in a micaceous rock at the Glenmalur lead-mines in the county of Wicklow, Ireland.*

* STEAM. See CALORIC, and VAPOUR.*

* STEARIN. See FAT.*

* STEATITE, or SOAPSTONE. A subspecies of rhomboidal mica. Colour grayish, or greenish white. Massive, disseminated, imitative, and in the following supposititious figures: an equiangular six-sided prism; an acute double six-sided pyramid; and a rhomboid. The first two are on rock crystal, the last on calcareous spar. Dull. Fracture coarse splintery. Translucent on the edges. Streak shining. Writes but feebly. Soft. Very sectile. Rather difficultly frangible. Does not adhere to the tongue. Feels very greasy. Sp. gr. 2.4 to 2.6. Infusible. Its constituents are, silica 44, magnesia 44, alumina 2, iron 7.3, manganese 1.5, chrome 2. Trace of lime and muriatic acid. It occurs frequently in small contemporaneous veins, that traverse serpentine in all directions; at Portsoy and Shetland; in the limestone of Icolmkill; in the serpentine of Cornwall: and in Anglesey. It is used in the manufacture of porcelain, and for taking greasy spots out of silk and woollen stuffs. It is also employed in polishing gypsum, serpentine, and marble. When pounded and slightly burned, it forms the basis of certain cosmetics. It writes readily on glass. Humboldt assures us, that the Otomacks, a savage race on the banks of the Orinoco, live for nearly three months of the year, principally on a kind of potter's clay; and many other savages eat great quantities of steatite, which contains absolutely no nourishment.*

* STEEL. A modification of iron, concerning which our knowledge is not very precise, notwithstanding the researches of many celebrated chemists. For the following important facts, I am indebted to the proprietor of the Monkland manufactory, where bar and cast steel of superior quality are made.

The chests or troughs, in which the iron bars are stratified, are 9 feet long, and composed of an open-grained siliceous freestone, unalterable by the fire. The Dannemora or Oregrounds iron is alone employed, for conversion into steel, at Monkland. The increase of weight is from 4 to 12 ounces per hundred weight. The average is therefore 1 in 224 parts. The first proportion constitutes mild, and the second very hard steel. Should the process be pushed much farther, the steel would then melt, and in the act of fusion would take a dose of charcoal sufficient to bring it to the state of No. 1. cast iron. The charcoal used in stratifying with the bar iron, is bruised so as to pass through a quarter-inch riddle. Whenever the interior of the troughs arrives at 70° Wedgwood, the carbon begins to be absorbed by the iron. There is no further diminution of the weight of the charcoal than what is due to this combination. What remains is employed at another charge. Great differences are found between the different kinds of bar iron, imported at the same time; which occasion unexpected differences in the resulting steel. The following letter contains important information from a gentleman possessing great experience in the manufacture of steel.

“ *Monkland Steel-Works*,
“ *9th November*, 1820.

“ SIR—Mr. William Murray has written me, that you wished I should communicate to you the reason why bar iron should run into the state of soft cast iron, by the operation being carried too far in the blister steel furnace; and how it does not make cast steel, as cast steel is said to be formed by the fusion of the blister steel in the crucible with charcoal.

“ The usual practice of making cast steel is to fuse common steel in a crucible, *without* any charcoal being mixed. The degree of hardness required in the cast steel is regulated by selecting blister steel of the proper degree of hardness for what is wanted.

“ This statement is made with a view to correct a common mistake, that to make cast steel it is necessary, and that it is the practice, to mix with the steel to be melted a quantity of charcoal.

“ Pursuing this mistake it naturally leads to others. Dr. Thomson says, when speaking on this subject, that cast steel is more fusible than common steel, and for that reason it cannot be welded to iron. It melts before it can he heated high enough; and that the quantity of carbon is greater than in common steel; and that this seems to constitute the difference between the two substances.

“ The statement of a simple fact will show that this conclusion is erroneous. Suppose a piece of blister steel, pretty hard, yet fit to stand the operation of welding to iron without any difficulty; let this steel be made into cast steel in the ordinary way. It will not then stand the process of welding. It will not melt before reaching the welding heat; but when brought to that heat, and submitted to the blows of the hammer, it will fall like a piece of sand, and the parts being once separated, they refuse to become again united. This difficulty of working the steel cannot arise from the steel containing more carbon, for the fact is, it contains less, part of it being burnt out in the operation of melting it. And if the same steel was to be melted a second time, more of the carbon would be burnt out, of course the steel would be softer; but at the same time the difficulty of working it would be increased; or, in other words, the red-short property it had acquired in the first melting would be doubly increased in the second, although a person who has not had the experience would very naturally conclude, that as the metal kept retrograding to the state of malleable iron, in the same proportion it would acquire all the properties of the metal in that state. When taking this view of the subject, it would appear that the difference between these two kinds of steel must arise from some other cause than that pointed out by Dr. Thomson.

"When the iron has absorbed a quantity of carbon in the blister steel furnace, sufficient to constitute steel of a proper degree of hardness, and the heat after this is continued to be kept up, the steel will keep absorbing more and more carbon. The fusibility of it will continue to increase, just in the same proportion, till at last it becomes so fusible, that even the limited heat of a blister steel furnace brings it down; and just at the time it is passing to the fluid state, it takes so great a quantity of charcoal, as changes it from the state of steel to that of cast iron. It appears to me, that the charcoal is combined in rich cast iron, in the mechanical state, and not in the chemical, as in steel.

"With this you will receive a specimen from the blister steel furnace. The fracture of the bar will show you steel in the highest state of combination with carbon in which it can exist; and another part of the same fracture presents the transition from the state of steel to that of cast iron. Should you require it, I will send you a specimen of cast steel in the ingot, and from the same ingot, one in the hammered state. I am," &c.

"John Buttery."*

* Steinheilite. Blue quartz of Finland.*

* Stibium. Antimony.*

* Stilbite, or Pyramidal Zeolite. See Zeolite.*

* Stilpnosiderite. Colour brownish-black. Massive, imitative, and in curved concretions. Splendent, resinous. Fracture conchoidal. Opaque. Streak yellowish-brown. Hard in a low degree. Brittle. Sp. gr. 3.77 With borax it gives a dark olive-green glass. Its constituents are, oxide of iron 80.5, silica 2.25, water 16, oxide of manganese a trace.—*Ullmann.* It is said to contain phosphoric acid. It occurs along with brown iron in Saxony and Bavaria. It is allied to meadow iron-ore.*

* Stones. See Analysis, Earths, Geology, Meteorolite, and Mineralogy.*

* Stinkstone, or Swinestone. A variety of compact lucullite, a sub-species of lime-stone.*

* Strahlstein. Actinolite.*

Strontia. About 35 years ago a mineral was brought to Edinburgh by a dealer in fossils, from a lead-mine at Strontian in Argyllshire, which was generally considered as a carbonate of barytes. It has since been found near Bristol, in France, in Sicily, and in Pennsylvania. Dr. Crawford first observed some differences between its solution in muriatic acid, and that obtained from the carbonate of barytes of Anglezark, and thence supposed it to be a new earth. Dr. Hope of Edinburgh had entertained the same opinion, and confirmed it by experiments in 1791. Kirwan, Klaproth, Pelletier, and Sulzer did the same. The carbonic acid may be expelled by a heat of 140° of Wedgwood, leaving the strontia behind; or by dissolving in the nitric acid, and driving this off by heat.

Pure strontia is of a grayish-white colour; a pungent acrid taste; and when powdered in a mortar, the dust that rises irritates the lungs and nostrils. Its specific gravity approaches that of barytes. It requires rather more than 160 parts of water at 60° to dissolve it; but of boiling water much less. On cooling, it crystallizes in thin, transparent, quadrangular plates, generally parallelograms, seldom exceeding a quarter of an inch in length, and frequently adhering together. The edges are most frequently bevelled from each side. Sometimes they assume a cubic form. These crystals contain about 68 of water; are soluble in 51.4 times their weight of water at 60°, and in little more than twice their weight of boiling water. They give a blood-red colour to the flame of burning alcohol. The solution of strontia changes vegetable blues to a green. Strontia combines with sulphur either in the wet or dry way, and its sulphuret is soluble in water.

In its properties, strontia has a considerable affinity to barytes. It differs from it chiefly in being infusible, much less soluble, of a different form, weaker in its affinities, and not poisonous. Its saline compounds afford differences more marked.—*Edinburgh Trans.*

* The basis of strontia, is strontium, a metal first procured by Sir *H. Davy* in 1808, precisely in the same manner as barium, to which it is very analogous, but has less lustre. It appeared *fixed*, difficultly fusible, and not volatile. It became converted into strontia by exposure to air,

and when thrown into water, decomposed it with great violence, producing hydrogen gas, and making the water a solution of strontia. By igniting the mineral strontianite (see HEAVY SPAR) intensely with charcoal powder, strontia is cheaply procured. Sir H. Davy, from indirect experiments, is disposed to regard it as composed of about 86 strontium + 14 oxygen, in 100 parts; and supposing it to be composed of a prime proportion of each constituent, the equivalent prime of strontium would be 6.143, and of strontia 7.143. But from the proportions of the constituents in the carbonate; the prime of strontia appears to be 6.4 or 6.5; and hence that of strontium will be 5.5.

The beautiful red fire which is now so frequently used at the theatres, is composed of the following ingredients: 40 parts dry nitrate of strontian, 13 parts of finely powdered sulphur, 5 parts of chlorate of potash (hyperoxymuriate), and 4 parts of sulphuret of antimony. The chlorate of potash and sulphuret of antimony should be powdered separately in a mortar, and then mixed together on paper; after which they may be added to the other ingredients, previously powdered and mixed. No other kind of mixture than rubbing together on paper is required. Sometimes a little realgar is added to the sulphuret of antimony, and frequently when the fire burns dim and badly, a very small quantity of very finely powdered charcoal or lampblack will make it perfect.

For the saline combinations of strontia, see the ACIDS at the begining of the Dictionary, or Dr. Hope's excellent original dissertation on this earth, in the Edin. Phil. Trans. for 1790.*

* **STRONTIANITE.** See HEAVY SPAR.*

* **STRONTITES.** The same as strontia.*

* **STRONTIUM.** The metallic base of strontia.*

* **STRYCHNIA.** This alkaline substance was detected by Pelletier and Caventou in the fruit of the *strychnos nux vomica*, and *strychnos ignatia*, about the end of the year 1818. It was obtained from the bean of the strychnos ignatia by the following process: The bean was rasped down as small as possible. It was then exposed to the action of nitric ether in a Papin's digester. The residue, thus deprived of a quantity of fatty matter, was digested in alcohol as long as that reagent was capable of dissolving any thing. The alcoholic solutions were evaporated to dryness, and the residue redissolved in water. Caustic potash being dropped into the solution, a white crystalline precipitate fell, which was strychnia. It was purified by washing it in cold water, dissolving it in alcohol, and crystallizing it. Strychnia was obtained likewise from the bean of the strychnos ignatia by boiling the infusion of the bean with magnesia, in the same manner as Robiquet had obtained morphia from the infusion of opium.

The properties of strychnia, when in a state of purity, are as follows:

It is crystallized in very small four-sided prisms, terminated by four-sided low pyramids. It has a white colour, its taste is intolerably bitter, leaving a metallic impression in the mouth. It is destitute of smell. It is not altered by exposure to the air. It is neither fusible nor volatile, except at temperatures at which it undergoes decomposition. It is charred at the temperature at which oil enters into ebullition (about 580°). When strongly heated, it swells up, blackens, gives out empyreumatic oil, a little water and acetic acid; carbonic acid and carburetted hydrogen gases are disengaged, and a bulky charcoal remains behind. When heated with peroxide of copper, it gives out only carbonic acid gas and water. It is very little soluble in cold water, 100,000 parts of that liquid dissolving only 15 parts of strychnia; but it dissolves in 2500 times its weight of boiling water. A cold solution of strychnia in water may be diluted with 100 times its volume of that liquid without losing its bitter taste.

When strychnia is introduced into the stomach, it acts with prodigious energy. A locked jaw is induced in a very short time, and the animal is speedily destroyed. Half a grain of strychnia blown into the throat of a rabbit proved fatal in five minutes, and brought on locked jaw in two minutes.

Sulphate of strychnia is a salt which crystallizes in transparent cubes, soluble in less than ten times its weight of cold water. Its taste is intensely bitter, and the strychnia is precipitated from it by all the soluble salifiable bases. It is not altered by exposure to the air. In the temperature of 212° it loses no weight, but becomes opaque. At a higher temperature it melts, and speedily congeals again, with a loss of three per cent of its weight. At a still higher temperature it is decomposed and charred. Its constituents are,

Sulphuric acid,	9.5	5.00
Strychnia,	90.5	47.63
	100.0	

Muriate of strychnia crystallizes in very small needles, which are grouped together, and before the microscope exhibit the form of quadrangular prisms. When exposed to the air, it becomes opaque. It is more soluble in water than the sulphate, has a similar taste, and acts with the same violence upon the animal economy as all the other salts of strychnia. When heated to the temperature at which the base is decomposed, it allows the muriatic acid to escape.

Phosphate of strychnia crystallizes in four-sided prisms. It can only be obtained neutral by double decomposition.

Nitrate of strychnia can be obtained only by dissolving strychnia in nitric acid, diluted with a great deal of water. The saturated solution, when cautiously evaporated, yields crystals of neutral nitrate in pearly needles. This salt is much more soluble in hot than in cold water. Its taste is exceedingly bitter, and it acts with more violence upon the animal economy than pure strychnia. It seems capable of uniting with an excess of acid. When heated, it becomes yellow, and undergoes decomposition. It is slightly soluble in alcohol, but is insoluble in ether.

When concentrated nitric acid is poured upon strychnia, it immediately strikes an amaranthine colour, followed by a shade similar to that of blood. To this colour succeeds a tint of yellow, which passes afterwards into green. By this action the strychnia seems to be altered in its properties, and to be converted into a substance still capable of uniting with acids.

Carbonate of strychnia is obtained in the form of white flocks, little soluble in water, but soluble in carbonic acid.

Acetic, oxalic, and tartaric acids form with strychnia neutral salts, which are very soluble in water, and more or less capable of crystallizing. They crystallize best when they contain an excess of acid. The neutral acetate is very soluble, and crystallizes with difficulty.

Hydrocyanic acid dissolves strychnia, and forms with it a crystallizable salt.

Strychnia combines neither with sulphur nor carbon. When boiled with iodine, a solution takes place, and iodate and hydriodate of strychnia are formed. Chlorine acts upon it precisely in the same way.

Strychnia, when dissolved in alcohol, has the property of precipitating the greater number of metallic oxides from their acid solutions. It is precipitated by the alkalis and alkaline earths; but the effect of the earths proper has not been tried. See *Ann. de Chim. et de Phys.* x. 142.*

* SUBER. Cork. See CERIN, and ACID (SUBERIC).*

SUBLIMATION is a process by which volatile substances are raised by heat, and again condensed in the solid form.

This operation is founded on the same principles as distillation, and its rules are the same, as it is nothing but a dry distillation. Therefore all that has been said on the article DISTILLATION is applicable here, especially in those cases where sublimation is employed to separate volatile substances from others which are fixed or less volatile.

Sublimation is also used in other cases: for instance, to combine volatile matters together, as in the operation of the sublimates of mercury; or to collect some volatile substances, as sulphur, the acid of borax, and all the preparations called flowers.

The apparatus for sublimation is very simple. A matrass or small alembic is generally sufficient for the sublimation of small quantities of matter. But the vessels and the method of managing the fire, vary according to the nature of the matters which are to be sublimed, and according to the form which is to be given to the sublimate.

The beauty of some sublimates consists in their being composed of very fine, light parts, such as almost all those called flowers; as flowers of sulphur, of benzoin, and others of this kind. When the matters to be sublimed are at the same time volatile, a high cucurbit, to which is adapted a capital, and even several capitals placed one upon another, are employed. The sublimation is performed in a sand-bath, with only the precise degree of heat requisite to raise the substance which is to be sublimed, and the capitals are to be guarded as much as possible from heat. The height of the cucurbit and of the capitals seems well contrived to accomplish this intention.

When along with the dry matter which is to be collected in these sublimations, a certain quantity of some liquor is raised, as happens in the sublimation of acid of borax, and in the rectification of volatile concrete alkali, which is a kind of sublimation, a passage and a receiver for these liquors must be provided. This is conveniently done by using the ordinary capital of the alembic, furnished with a beak and a receiver.

Some sublimates are required to be in masses as solid and compact as their natures allow. Of this number are camphor, muriate of ammonia, and all the sublimates of mercury. The properest vessels for these sublimations are bottles or matrasses, which are to be sunk more or less deeply in sand, according to the volatility and gravity of the matters that are to be sublimed. In this manner of subliming, the substances having quitted the bottom of the vessel, adhere to its upper part; and as this part is low and near the fire, they there suffer a degree of heat sufficient to give them a kind of fusion. The art, therefore, of conducting these sublimations consists in applying such a degree of heat, or in so disposing the sand (that *is, making* it cover more or less the matrass), that the heat in the upper part of the matrass shall be sufficient to make the *sublimate* adhere to the glass, and to give it such a degree of fusion as is necessary to render it compact; but at the same time this heat must not be so great as to force the sublimate through the neck of the matrass, and dissipate it. These conditions are not easily to be attained, especially in great works.

Many substances may be reduced into flowers and sublimed, which require for this purpose a very great heat, with the access of free air and even the contact of coals, and therefore cannot be sublimed in close vessels. Such are most soots or flowers of metals, and even some saline substances. When these sublimates are required, the matters from which they are to be separated must be placed among burning coals in open air; and the flowers are collected in the chimney of the furnace in which the operation is performed. The tutty, calamine, or pompholix, collected in the upper part of furnaces in which ores are smelted, are sublimates of this kind.

Subsalt. A salt having an excess of base beyond what is requisite for saturating the acid, as *supersalt* is one with an excess of the acid. Thus sulphate of potash is the neutral compound of sulphuric acid and potash; subsulphate of potash, a compound of the same ingredients, in which there is an excess of base; supersulphate of potash, a compound of the same acid and the same base, in which there is an excess of acid. The term was introduced by Dr. Pearson.

* **Succinates.** Compounds of succinic acid with the salifiable bases.*

* **Succinic Acid.** See Acid (Succinic.)*

Sugar is a constituent part of vegetables, existing in considerable quantities in a number of plants. It is afforded by the maple, the birch, wheat, and Turkey corn. Margraaf obtained it from the roots of beet, red beet, skirret, parsnips, and dried grapes. The process of this chemist consisted in digesting these roots, rasped, or finely divided, in alcohol. This fluid dissolves the sugar; and leaves the extractive matter untouched, which falls to the bottom.

In Canada, the inhabitants extract sugar from the maple. At the commencement of spring, they heap snow in the evening at the foot of the tree, in which they previously make apertures for the passage of the returning sap. Two hundred pounds of this juice, afford by evaporation fifteen of a brownish sugar. The quantity prepared annually, amounts to fifteen thousand weight.

Dr. Rush, in the Transactions of the American Philosophical Society, vol. iii. has given an account at length, of the sugar maple tree, of which the following is a short abstract:—

The *acer saccharinum* of Linnæus, or sugar maple tree, grows in great quantities in the western counties of all the middle States of the American Union. It is as tall as the oak, and from two to three feet in diameter; puts forth a white blossom in the spring, before any appearance of leaves; its small branches afford sustenance for cattle, and its ashes afford a large quantity of excellent potash. Twenty years are required for it to attain its full growth. Tapping does not injure it; but, on the contrary, it affords more sirup, and of a better quality, the oftener it is tapped. A single tree has not only survived, but flourished, after tapping, for forty years. Five or six pounds of sugar are usually afforded by the sap of one tree; though there are instances of the quantity exceeding twenty pounds. The sugar is separated from the sap either by freezing, by spontaneous evaporation, or by boiling. The latter method is the most used. Dr. Rush describes the process; which is simple, and practised without any difficulty by the farmers.

From frequent trials of this sugar, it does not appear to be in any respect inferior to that of the West Indies. It is prepared at a time of the year when neither insect, nor the pollen of plants exist to vitiate it, as is the case with common sugar. From calculations grounded on facts, it is ascertained, that America is now capable of producing a surplus of one-eighth more than its own consumption; that is, on the whole, about 135,000,000 pounds; which, in the country, may be valued at fifteen pounds weight for one dollar.

The Indians likewise extract sugar from the pith of the bamboo.

The beet has lately been much cultivated in Germany, for the purpose of extracting sugar from its root. For this the roots are taken up in autumn, washed clean, wiped, sliced lengthwise, strung on threads, and hung up to dry. From these the sugar is extracted by maceration in a small quantity of water; drawing off this upon fresh roots, and adding fresh water to the first roots, which is again to be employed the same way, so as to get out all their sugar, and saturate the water as much as possible with it. This water is to be strained and boiled down for the sugar.

Some merely express the juice from the fresh roots, and boil this down; others boil the roots; but the sugar extracted in either of these ways is not equal in quality to the first.

Professor Lampadius obtained from 110 lbs. of the roots, 4 lbs. of well grained white powder sugar; and the residuums afforded 7 pints of a spirit resembling rum. Achard says, that about a ton of roots produced him a 100 lbs. of raw sugar, which gave 55 lbs. of refined sugar, and 25 lbs. of treacle.

But the sugar which is so universally used, is afforded by the sugar cane (*arundo saccharifera,*) which is raised in our colonies. When this plant is ripe, it is cut down, and crushed by passing it between iron cylinders placed perpendicularly, and moved by water or animal strength. The juice which flows out by this strong pressure is received in a shallow trough placed beneath the cylinder. This juice is called in the French sugar colonies *vesou;* and the cane, after having undergone this pressure, is called *begasse.* The juice is more or less saccharine, according to the nature of the soil on which the cane has grown, and the weather that has predominated during its growth. It is aqueous when the soil or the weather has been humid; and in contrary circumstances it is thick and glutinous.

The juice of the cane is conveyed into boilers, where it is boiled with wood ashes and lime. It is subjected to the same operation in three several boilers, care being taken to remove the scum as it rises. In this state it is called *sirup;* and is again boiled with lime and alum till it is sufficiently concentrated, when it is poured into a vessel called the *cooler*. In this vessel it is agitated with wooden stirrers, which break the crust as it forms on the surface. It is afterward poured into casks, to accelerate its cooling; and while it is still warm, it is conveyed into barrels standing upright over a cistern, and pierced through their bottom with several holes stopped with cane. The sirup which is not condensed filters through these canes into the cistern beneath; and leaves the sugar in the state called *coarse sugar*, or *muscovado.* This sugar is yellow and fat, and is purified in the islands in the following manner. The sirup is boiled, and poured into conical earthen vessels, having a small perforation at the apex, which is kept closed. Each cone, reversed on its apex, is supported in another earthen vessel. The sirup is stirred together, and then left to crystallize. At the end of fifteen or sixteen hours, the hole in the point of each cone is opened, that the impure sirup may run out. The base of these sugar loaves is then taken out, and white pulverized sugar substituted in its stead; which being well pressed down, the whole is covered with clay, moistened with water. This water filters through the mass, carrying the sirup with it which was mixed with the sugar, but which by this management flows into a pot substituted in the place of the first. This second fluid is called *fine sirup.* Care is taken to moisten and keep the clay to a proper degree of softness, as it becomes dry. The sugar loaves are afterward taken out, and dried in a stove for eight or ten days; after which they are pulverised, packed, and exported to Europe, where they are still farther purified.

The operation of the French sugar refiners consists in dissolving the cassonade, or clayed sugar, in lime-water. Bullocks' blood is added, to promote the clarifying; and, when the liquor begins to boil, the heat is diminished, and the scum carefully taken off. It is in the next place concentrated by a brisk heat; and, as it boils up, a small quantity of butter is thrown in, to moderate its agitation. When the boiling is sufficiently effected, the fire is put out; the liquor is poured into moulds, and agitated, to mix the sirup together with the grain sugar already formed. When the whole is cold, the moulds are opened, and the loaves are covered with moistened clay, which is renewed from time to time till the sugar is well cleansed from its sirup. The loaves being then taken out of the moulds, are carried to a stove, where they are gradually heated to 145° F. They remain in this stove eight days, after which they are wrapped in blue paper for sale.

The several sirups, treated by the same methods, afford sugars of inferior qualities; and the last portion, which no longer affords any crystals, is sold by the name of *molasses.* The Spaniards use this molasses in the preparation of sweetmeats.

A solution of sugar, much less concentrated than that we have just been speaking of, lets fall by repose crystals, which affect the form of tetrahedral prisms, terminated by dihedral summits, and known by the name of *sugarcandy.*

The preceding account of the manufacture of sugar in the colonies is chiefly extracted from Chaptal. The following is taken from Edwards' History of the West Indies, the authority of which is indubitable.

Such planters as are not fortunately furnished with the means of grinding their canes by water, are at this season frequently impeded by the failure or insufficiency of their mills; for though a sugar mill is a very simple contrivance, yet great force is requisite to make it vanquish the resistance which it necessarily meets with. It principally consists of three upright iron rollers or cylinders, from thirty to forty inches in length, and from twenty to twenty-five inches in diameter; and the middle one, to which the moving power is applied, turns the other two by means of cogs. The canes, which are previously cut short and tied into bundles, are twice compressed between these rollers; for after they have passed through the first and second rollers, they are turned round the middle one by a piece of frame work of a circular form, which is called in Jamaica the dumb-returner, and forced back through the second and third. By this operation they are squeezed completely dry, and sometimes even reduced to powder. The cane-juice is received in a leaden bed, and thence conveyed into a vessel called the receiver. The refuse, or macerated rind of the cane, which is called cane-trash, serves for fuel to boil the liquor.

The juice from the mill usually contains eight parts of pure water, one part of sugar, and one part made up of gross oil and mucilage, with a portion of essential oil. The proportions are taken at a medium; for some juice has been so rich as to make a hogshead or sixteen hundred weight of sugar from thirteen hundred gallons, and some is so watery as to require more than double that quantity. The richer the juice is, the less it abounds with redundant oil and gum; so that very little knowledge of the contents of any other quantity can be obtained by the most exact analysis of any one quantity of juice.

The following matters are likewise usually contained in cane-juice. Some of the green tops, which serve to tie the canes in bundles, are often ground in, and yield a raw acid juice exceedingly disposed to ferment and render the whole liquor sour. Beside these they grind in some pieces of the ligneous part of the cane, some dirt, and lastly, a substance of some importance, which may be called the crust. This substance is a thin black coat of matter that surrounds the cane between the joints, beginning at each joint, and gradually growing thinner the farther from the joint upwards, till the upper part between the joints appears entirely free from it, and resumes its bright yellow colour. It is a fine black powder, that mixes with the clammy exudations from the cane; and as the fairness of the sugar is one symptom of its goodness, a small quantity of this crust must very much prejudice the commodity.

The sugar is obtained by the following process:—The juice or liquor runs from the receiver to the boiling-house, along a wooden gutter lined with lead. In the boiling-house, it is received into one of the copper pans or caldrons, called clarifiers. Of these there are generally three; and their dimensions are determined by the power of supplying them with liquor. There are water mills that will grind with great facility sufficient for thirty hogsheads of sugar in a week. Methods of quick boiling cannot be dispensed with on plantations thus fortunately provided; for otherwise the cane liquor would unavoidably become tainted before it could be exposed to the fire. The purest cane-juice will not remain twenty minutes in the receiver without fermenting. Hence, clarifiers are sometimes seen of one thousand gallons each. But on plantations that, during crop time, make from fifteen to twenty hogsheads of sugar a-week, three clarifiers of three or four hundred gallons each are sufficient. The liquor, when clarified, may be drawn off at once, with pans of this size, and there is leisure to cleanse the vessels every time they are used. Each clarifier is furnished either with a siphon or cock for drawing off the liquor. It has a flat bottom, and is hung to a separate fire, each chimney having an iron slider, which, when shut, causes the fire to be extinguished through want of air §

As soon as the stream from the receiver has filled the clarifier with fresh liquor, and the fire is lighted, the temper, which is generally Bristol white-lime in powder, is stirred into it. This is done, in order to neutralize the superabundant acid, and to get rid of which is the greatest difficulty in sugar making. Alkali, or lime, generally effects this; and at the same time, part of it is said to become the basis of the sugar. Mr. Edwards affirms, that it affects both the smell and taste of the sugar. It falls to the bottom of the pans in a black insoluble matter, which scorches the bottom of the vessels, and cannot without difficulty be detached from them. But, in order that less of the lime may be precipitated to the bottom, little more than half a pint of Bristol lime should be allowed to every hundred gallons of liquor, and Mr. Bousie's method of dissolving it in boiling water previous to mixing it with the cane-juice should be adopted ‡

As the force of the fire increases, and the liquor grows hot, a scum is thrown up, which is formed of the gummy matter of the cane, with some of the oil, and such impurities as the mucilage is able to entangle. The heat is now suffered to increase gradually till it nearly rises to the heat of boiling water. The liquor, however, must by no means be suffered to boil. When the scum begins to rise into blisters, which break into white froth, and generally appear in about forty minutes, it is known to be sufficiently heated. Then the damper is applied, and the fire extinguished; and, if circumstances will admit, the liquor after this is suffered to remain a full hour undisturbed. In the next place, it is carefully drawn off, either by a siphon, which draws up the clear fluid through the scum, or by means of a cock at the bottom. In either case, the scum sinks down without breaking as the liquor flows; for its tenacity prevents any admixture. The liquor is received into a gutter or channel, which conveys it to the evaporating boiler, commonly called the grand copper; and if produced at first from good and untainted canes, it will then appear almost transparent.

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§ The clarifiers are generally placed in the middle or at one end of the boiling-house. When they are placed at one end, the boiler called the *teache* is placed at the other, and three boilers are usually ranged between them. The teache commonly holds from 70 to 100 gallons, and the boilers between the clarifiers and teache diminish in size from the first to the last. But when the clarifiers are in the middle, there is generally a set of three boilers on each side, which in effect form a double boiling-house. This arrangement is very necessary on large estates.

‡ Mr. Bousie, to whom, for his improvements in the art of sugar-boiling, the Assembly of Jamaica gave 1000*l*, in a paper which he distributed among the members, recommends the use of vegetable alkali, or ashes of wood, such as pimento tree, dumb cane, fern tree, cashew, or logwood, as affording a better temper than quicklime. Afterward, however, he was convinced, that sugar formed on the basis of fixed alkaline salts never stands the sea, unless some earth is united to the salts Such earth as approaches nearest to the basis of alum, Mr. Edwards thinks, would be most proper; and it deserves to be inquired, how far a proper mixture of vegetable alkaline salts and lime might prove a better temper than either lime or alkaline salts alone. In some parts of Jamaica, where the cane-liquor was exceedingly rich, Mr. Bousie made very good sugar without a particle of temper.

In the grand or evaporating copper, which should be sufficiently large to receive the net contents of one of the clarifiers, the liquor is suffered to boil, and the scum, as it rises, is continually taken off by large scummers, till the liquor becomes finer and somewhat thicker. This operation is continued, till the subject is so reduced in quantity, that it may be contained in the next or second copper, into which it is then ladled. The liquor is now almost of the colour of Madeira wine. In the second copper the boiling and scumming are continued: and if the subject be not so clean as is expected, lime-water is thrown into it. This addition not only serves to give more temper, but likewise to dilute the liquor, which sometimes thickens too fast to permit the feculencies to rise in the scum. When the froth in boiling arises in large bubbles, and is not much discoloured, the liquor is said to have a favourable appearance in the second copper. When, in consequence of such scumming and evaporation, the liquor is again so reduced, that it may be contained in the third copper, it is ladled into it, and so on to the last copper, which is called the teache. This arrangement supposes four boilers or coppers, besides the three clarifiers.

In the teache the subject undergoes another evaporation, till it is supposed boiled enough to be removed from the fire. This operation is usually called striking, *i. e.* ladling the liquor, which is now exceeding thick, into the cooler.

The cooler, of which there are generally six, is a shallow wooden vessel, about eleven inches deep, seven feet in length, and from five to six feet wide. A cooler of this size holds a hogshead of sugar. Here the sugar grains, *i. e.* as it cools, it runs into a coarse irregular mass of imperfect crystals, separating itself from the molasses. From the cooler it is taken to the curing-house, where the molasses drains from it.§

But here it may be proper to notice the rule for knowing when the subject is fit to be ladled from the teache to the cooler. Many of the negro boilers, from long habit, guess accurately by the eye alone, judging by the appearance of the grain on the back of the ladle; but the practice generally adopted is to judge by what is called the touch, *i. e.* taking up with the thumb a small portion of the hot liquor from the ladle, and, as the heat diminishes, drawing with the forefinger the liquid into a thread. This thread will suddenly break and shrink from the thumb to the suspended finger, in different lengths, according as the liquor is more or less boiled. A thread of a quarter of an inch long generally determines the proper boiling height for strong muscovado sugar.‡

The curing-house is a large airy building, provided with a capacious molasses cistern, the sides of which are sloped and lined with terras, or boards. A frame of massy joist-work without boarding, is placed over this cistern; and empty hogsheads without headings are ranged on the joints of this frame. Eight or ten holes are bored in the bottoms of these hogsheads, and through each of the holes the stalk of a plantain leaf is thrust six or eight inches below the joists, and long enough to stand upright above the top of the hogshead. Into these hogsheads, the mass from the cooler is put, which is called potting; and the molasses drains through the spongy stalk, and drops into the cistern, whence it is occasionally taken for distillation. In the space of three weeks, the sugar becomes tolerably dry and fair. It is then said to be cured, and the process is finished.

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§ It is necessary to observe in this place, that, in order to obtain a large-grained sugar, it must be suffered to cool slowly and gradually. If the coolers be too shallow, the grain is injured in a surprising manner.

‡ The vessel called the teache probably derived its name from this practice of trying by the touch (tactio.) Some years ago, John Proculus Baker, Esq. barrister at law, recommended to the public a method more scientific and certain, in a treatise which he published in 1775, entitled, An Essay on the Art of making Muscovado Sugar. *It is as* follows: "Provide a small thin pane of clear crown glass, set in a frame, which I would call a tryer; on this drop two or three drops of the subject, one on the other, and carry your tryer out of the boiling-house into the air. Observe your subject, and more particularly whether it grain freely, and whether a small edge of molasses separate at the bottom. I am well satisfied, that a little experience will enable you to judge what appearance the whole skip will put on when cold, by this specimen, which is also cold. This method is used by chemists, to try evaporated solutions of all other salts: it may seem therefore somewhat strange, it has not been long adopted in the boiling-house."

Sugar thus obtained is called muscovado, and is the raw material whence the British sugar-bakers chiefly make their loaf or refined lump. There is another sort, which was formerly much used in Great Britain for domestic purposes, and was generally known by the name of Lisbon sugar. In the West Indies, it is called clayed sugar; and the process of making it is as follows;—

A quantity of sugar from the cooler is put into conical pots or pans, which the French call *formes*, with the points downward, having a hole about half an inch in diameter at the bottom, for the molasses to drain through, but which at first is closed with a plug. As soon as the sugar in these pots is cool, and becomes a fixed body, which is known by the middle of the top falling in, the plug is taken out, and the pot placed over a large jar, intended to receive the sirup or molasses that drain from it. In this state it is left as long as the molasses continues to drop, when a stratum of clay is spread on the sugar, and moistened with water. This, imperceptibly oozing through the pores of the clay, dilutes the molasses, in consequence of which more of it comes away than from sugar cured in the hogshead, and the sugar of course becomes so much whiter and purer. According to Sloane, the process was first discovered in Brasil, by accident: "A hen," says he, "having her feet dirty, going over a pot of sugar, it was found under her feet to be whiter than elsewhere." The reason assigned why this process is not universally adopted in the British sugar islands is this, that the water which dilutes and carries away the molasses, dissolves and carries with it so much of the sugar, that the difference in quality does not pay for the difference in quantity. It is probable, however, that the French planters are of a different opinion: for upwards of four hundred of the plantations of St. Domingo have the necessary apparatus for claying, and actually carry on the system.

Sugar is very soluble in water, and is a good medium for uniting that fluid with oily matters. It is much used for domestic purposes, and appears on the whole to be a valuable and wholesome article of food, the uses of which are most probably restricted by its high price. This price may in a certain degree arise from the nature of the article, and its original cost; but is no doubt in a great measure owing to the inhuman and wasteful culture by slaves, and the absurd principles of European colonization, duties, drawbacks, and bounties, which have the effect to create unnatural monopolies, and to prevent commerce from finding its level. This is eminently the case with regard to our West-India islands, and their produce.

It appears that sugar has the property of rendering some of the earths soluble in water. This property was accidentally discovered by Mr. William Ramsay of Glasgow.

Being employed in making experiments on sugar, and happening to put some quicklime into a cold solution of it, he noticed, that it had acquired an uncommon caustic taste.

Hence he concluded, that sugar possesses the property of dissolving a certain proportion of lime; and in order to ascertain its capacity in this respect, experiments were made upon this earth, together with strontites, magnesia, and barytes.

Sugar, dissolved in water at the temperature of 50°, is capable of dissolving one-half of its weight of lime.

The solution of lime in sugar is of a beautiful white-wine colour, and has the smell of fresh slaked quicklime

It is precipitated from the solution, by the carbonic, citric, tartaric, sulphuric, and oxalic acids; and it is decomposed, by double affinity, by caustic and carbonated potash and soda, the citrate, tartrate, and oxalate of potash, &c.

An equal weight of strontia, with the sugar employed, is capable of being dissolved at the temperature of 212°, and of being retained in solution by the sugar at 50° of Fahrenheit. On exposing the crystals which had fallen down during the cooling of the liquid, to the air of the atmosphere, they attracted carbonic acid, and effloresced.

The solution of strontia in sugar is of a fine white-wine colour, and, like that of lime, has a peculiar caustic smell. This earth is precipitated by caustic and carbonated potash and soda; also by the carbonic, citric, tartaric, sulphuric, and oxalic acids; and it is decomposed, by compound affinity, by the carbonates of potash and soda; also by the citrate, tartrate, and oxalate of potash.

The solution of magnesia in sirup, like those of lime and strontia, was of a pure white colour, and had no sensible variation in smell or taste from the common solution of sugar, farther than that the sweet seemed much improved, and was softer and more agreeable to the palate, as if it were entirely freed from the earthy taste, which unrefined sugar frequently has. On its remaining at rest for some months, in a bottle well corked, the magnesia appears to be entirely separated.

Very little alumina is dissolved by a solution of sugar, when fresh precipitated earth is presented to it, either in the cold or hot state.

The union of the sugar with the alkalis, has been long known; but this is rendered more strikingly evident, by carbonated potash or soda, for instance, decomposing the solutions of lime and strontia in sugar, by double affinity.

In making solutions of unrefined sugar for culinary purposes, a gray-coloured substance is found frequently precipitated. It is probable, that this proceeds from a superabundance of lime, which has been used in clarifying the juice of the sugar-cane at the plantations abroad. Sugar with this imperfection is known among the refiners of this article by the name of *weak*. And it is justly termed so, the precipitated matter being nothing but lime which has attracted carbonic acid from the sugar, (of which there is a great probability,) or from the air of the atmosphere. A bottle in which I had kept a solution of lime in sugar for at least four years, closely corked, was entirely incrusted with a yellowish-coloured matter, which on examination was found to be entirely carbonate of lime.

* In the ordinary refining of raw sugars, from twenty to thirty-five *per cent* of molasses are separated, of which a considerable part, probably two-thirds, are formed by the high heat used in the concentration of the sirup. Various plans have been contrived to diminish this production of molasses. One of these consisted in surrounding the sugar-boiler with oil or steam at a high temperature, instead of exposing it to a naked fire. In a second, the boiler is covered at top, and by means of an air-pump the atmospheric pressure is removed, so as to favour ebullition, and rapid evaporation, at moderate heats.

The celebrated chemist, Mr. Howard, took out a patent for this plan, which is undoubtedly the most scientific and productive of any; but requires superior skill and very minute attention in the manufacturer. No blood is used for clarification. This is accomplished by a system of most ingenious canvas filters, aided by the intermixture with the sirup, of a small quantity of pasty gypsum and alumina, made by saturating a solution of alum with quicklime. In the final purification, the base of the inverted sugar cone, is covered with a stratum of very pure saturated sirup, instead of moist pipe-clay.

The third method is founded on the property which animal charcoal (bone-black) possesses, of destroying vegetable colouring matter. Perhaps the combination of the last two modes promises the best results.

A fourth process for refining sugar is that of Mr. Daniel Wilson, for which a patent was granted. The specification is in the 24th vol. of the Repertory, p. 134.

The pan is to be charged with strong lime-water, the sugar added, and the fire set in the usual manner. For every hundred weight of sugar used, a solution is to be made of four ounces of sulphate of zinc, in as small a quantity of water as will dissolve it. When the sugar in the pan is melted, the solution of sulphate of zinc is added, and the whole well stirred. The oxide of zinc combines with the extractive matter, tannin and gallic acid, and renders them insoluble, while the sulphuric acid, in combination with the lime, becomes also insoluble. When raw sugar contains much acid, and a strong grain is required, take one ounce of lime in powder for every four ounces of sulphate of zinc, and as much water as will form a milk of lime, which is added to the solution of sugar in the pan, about five minutes after the solution of sulphate of zinc has been added. This purification of sugar by separating impurities chemically combined with it, is employed with much advantage in conjunction with the patent filtering apparatus invented by Mr. John Sutherland. The solution of sugar brought to the boiling point is run through the filter, and afterwards boiled to a proof. Mr. Wilson boils the sirup in a pan, having a coil of tinned copper or pure tin tubes placed along its bottom and sides, through which a constant stream of strongly heated oil, or other fatty matter, is made to pass. The oxide of zinc, precipitated previously by adding a solution of the salt to lime-water, is also recommended, as well as the oxide of tin.

Mr. Kirchoff, an ingenious Russian chemist accidentally discovered, that starch is convertible into sugar, by being boiled for some time with a very dilute sulphuric acid. Saussure showed, that 100 parts of starch yield 110 of sugar. He concluded, that this sugar is merely a compound of water and starch. According to his analysis, starch consists of

Oxygen,	55.87
Carbon,	37.29
Hydrogen,	6.84
	100.00

Sugar of grapes, according to the same chemist, is composed of

Oxygen,	56.51
Carbon,	36.71
Hydrogen,	6.78
	100.00

Common sugar has been analyzed by many eminent chemists. The following is a general view of the results:

	Gay-Lussac and Thenard.	Berzelius. Mean of 3.	Prout.
Oxygen,	50.63	49.856	53.33
Carbon,	42.47	43.265	39.99
Hydrogen,	6.90	6.879	6.66
	100.00	100.000	100.00

For a view of the proportions of the constituents referred to equivalent primes or volumes, see FERMENTATION, *column* 4. I am happy to observe, that Dr. Prout's experimental results agree with M. Gay-Lussac's theory, of sugar being a compound of 40 parts of carbon + 60 of water, or its elements. By Berzelius' analysis, starch consists of

Oxygen,	49.5
Carbon,	43.5
Hydrogen,	7.0
	100.0

The abstraction of a little hydrogen and carbon, would convert it into sugar. But no carbonic acid or other gas is extricated during the conversion, according to Vogel's experiments. I find that potatoes digested with dilute sulphuric acid, yields sugar cheaply and abundantly. The acid is afterwards removed by chalk; and the strained liquor left to repose, after due evaporation, affords crystals of sugar. From starch sugar, good beer has been made. I would recommend potatoes for this purpose. They are washed, grated down, and treated with the dilute acid for a day or two at a temperature of 212°.

M. Braconnot has recently extended our views concerning the artificial production of sugar and gum. Sulphuric acid (sp. gr. 1.827) mixed with well dried elm dust, became very hot, and on being diluted with water, and neutralized with chalk, afforded a liquor, which became gummy on evaporation. Shreds of linen triturated in a glass mortar, with sulphuric acid, yield a similar gum. Nitric acid has a similar power. If the gummy matter from linen be boiled for some time with dilute sulphuric acid, we obtain a crystallizable sugar, and an acid, which M. Braconnot calls the vegeto-sulphuric acid. The conversion of wood also into sugar, will no doubt appear remarkable; and when persons not familiarized with chemical speculations are told, that a pound weight of rags can be converted into more than a pound weight of sugar, they may regard the statement as a piece of pleasantry, though nothing, says M. Braconnot, can be more real.

Silk is also convertible into gum by sulphuric acid. Twelve grammes of glue, reduced to powder, were digested with a double weight of concentrated sulphuric acid without artificial heat. In twenty hours the liquid was not more coloured than if mere water had been employed. A decilitre of water was then added, and the whole was boiled for 5 hours, with renewal of the water, from time to time, as it wasted. It was next diluted, saturated with chalk, filtered and evaporated to a sirupy consistence, and left in repose for a month. In this period a number of granular crystals had separated, which adhered pretty strongly to the bottom of the vessel, and had a very decided saccharine taste. This sugar crystallizes much more easily than cane sugar. The crystals are gritty under the teeth, like sugar-candy; and in the form of flattened prisms or tabular groups. Its taste is nearly as saccharine as grape sugar; its solubility in water, scarcely exceeds that of sugar of milk. Boiling alcohol, even when diluted, has no action on this sugar. By distillation it yields ammonia, indicating the presence of azote. This sugar combines intimately with nitric acid, without sensibly decomposing it, even with the assistance of heat, and there results a peculiar crystallized acid, to which the name nitro-saccharine has been given. *Annales de Chimie*, xii. or *Tilloch's Magazine*, vol. 55, *and* 56.

The varieties of sugar are; cane sugar, maple sugar, liquid sugar of fruits, sugar of figs, sugar of grapes, starch sugar, the mushroom sugar of Braconnot, manna, sugar of gelatin, sugar of honey, and sugar of diabetes. "The relation," says Dr. Prout, "which exists between urea and sugar, seems to explain in a satisfactory manner the phenomena of diabetes, which may be considered as a depraved secretion of sugar. The weight of the atom of sugar, is just half that of the weight of the atom of urea; the absolute quantity of hydrogen in a given weight of both is equal; while the absolute quantities of carbon and oxygen in a given weight of sugar, are precisely twice those of urea."

The constituents of these two bodies and lithic acid, are thus expressed by that ingenious philosopher.

ELEMENTS.	UREA.			SUGAR.			LITHIC ACID.		
	No.	Per Atom.	Per Cent.	No.	Per Atom.	Per Cent.	No.	Per Atom.	Per Cent.
Hydrogen,	2	2.5	6.66	1	1.25	6.66	1	1.25	2.85
Carbon,	1	7.5	19.99	1	7.50	39.99	2	15.00	34.28
Oxygen,	1	10.0	26.66	1	10.00	53.33	1	10.00	22.85
Azote,	1	17.5	46.66				1	17.50	40.00
	5	37.5	100.00	3	18.75	100.00	5	43.75	100.00

The foregoing compounds appear to be formed by the union of more simple compounds; as sugar, of carbon and water; urea, of carburetted hydrogen and nitrous oxide; lithic acid, of cyanogen and water, &c. whence it is inferred, that their artificial formation falls within the limits of chemical operations.*

* **Sugar of Lead.** Acetate of lead. See Lead.*

* **Sulphates.** Definite compounds of sulphuric acid with the salifiable bases. See Acid (Sulphuric,) and the respective bases.*

* **Sulphites.** Definite compounds of sulphurous acid with the bases.*

* **Sulphur.** Of native or prismatic sulphur, there are two species, the common and volcanic; the former is of two kinds compact and earthy sulphur.

§ 1. *Compact common sulphur.* Colour sulphur-yellow, and yellow of other shades. Massive, disseminated, and crystallized. Its primitive figure is a pyramid of 107° 19′, and 84° 24′; basis = 102° 41′. The secondary figures are, the primitive variously truncated, or acuminated, and delicate acicular crystals. Shining or glimmering. Cleavage prismatic and axifrangible. Fracture uneven. Translucent. Refracts double. Harder than talc. Brittle. When rubbed, it exhales a faint sulphureous smell, and becomes resino-electric. Sp. gr. 1.9 to 2.1. It occurs in considerable abundance in primitive mountains, in a state of combination with metals, forming the different genera of pyrites, glance and blende. In secondary mountains it is more abundant in the pure uncombined state. It is found in the island of Iceland, associated with gypsum; or in crusts investing alluvial substances. Very superb specimens of crystallized sulphur are found at Conil near Cape Trafalgar. It occurs abundantly in Sicily, at Urbino in the Papal States, in Arragon in Spain, and Lauenstein in Hanover.

§ 2. *Earthy common sulphur.* Colour pale straw-yellow. Massive and disseminated. Dull. Fracture fine earthy. Opaque. Does not soil. Soft to friable. It occurs in drusy cavities in flint, and along with the compact varieties, in gypsum and other rocks.

2. *Volcanic sulphur.* Colour pale sulphur-yellow. Massive, imitative, and crystallized in pyramids. Glistening, inclining to adamantine. Fracture uneven. Slightly translucent. It occurs abundantly at Solfatera in the neighbourhood of Vesuvius, and in Iceland.—*Jameson.**

* **Sulphur.** A simple inflammable body, of great importance in chemistry and the arts. To the properties above mentioned, we shall here add, that its fusing point is about 220° F., before which temperature, it begins to evaporate. At 560°, it takes fire in the open air, and burns with a pale blue flame. When kept melted in an open vessel for some time, at about 300° F., it becomes thick and viscid; and if it be then poured into a basin of water, it appears of a red colour, and ductile like wax. In this state, it is used for taking impressions of seals or medals. Its sp. gr. is said to be increased from 1.99 to 2.325. This change is not owing to oxidation, for it takes place in close vessels.

When a roll of sulphur is suddenly seized in a warm hand, it crackles, and sometimes falls in pieces. This is owing to the unequal action of heat, on a body which conducts that power slowly, and which has little cohesion. If a mass of sulphur be melted in a crucible, and after the surface begins to concrete, if the liquid matter below be allowed to run out, fine acicular crystals of sulphur will be obtained.

Sulphur is insoluble in water; but in small quantity in alcohol and ether, and more largely in oil.

Sulphur combines with oxygen in four definite proportions, constituting an interesting series of acids, See Acid (Sulphuric.)

From these combinations it is inferred, that the prime equivalent of sulphur is 2; and the density of its vapour is 1.111 = that of oxygen gas.

Sulphur combines readily with chlorine. This compound was first made by Dr. Thomson, who passed chlorine gas through flowers of sulphur. It may be made more expeditiously by heating sulphur in a retort containing chlorine. The sulphur and chlorine unite, and form a fluid substance, which is volatile, below 200° F., and distils into the cold part of the retort. This substance, seen by reflected light, appears of a red colour, but is yellowish-green when seen by transmitted light. It smokes when exposed to air, and has an odour somewhat resembling that of sea-weed, but much stronger; it affects the eyes like the smoke of peat. Its taste is acid, hot, and bitter. Its sp. gr. is 1.7.

It does not redden perfectly dry paper tinged with litmus; when it is agitated in contact with water, the water becomes cloudy from the appearance of sulphur, and strongly acid, and it is found to contain oil of vitriol.

According to Sir H. Davy's experiments, 10 grains of pure sulphur absorb nearly 30 cubic inches of chlorine; so that the compound contains about 2. sulphur to 4.5 chlorine, or a prime equivalent of each.

The compound formed in the manner above described, cannot be made to unite to more chlorine; but it can dissolve a considerable portion of sulphur by heat, and becomes of a tawny-yellow colour.

Iodide of sulphur is easily formed by mixing the two ingredients in a glass tube, and exposing them to such a heat as melts the sulphur. It is grayish-black, and has a radiated structure like that of sulphuret of antimony. When distilled with water, iodine is disengaged.

Sulphur and hydrogen combine. Their union may be effected, by causing sulphur to sublime in dry hydrogen in a retort. There is no change of volume; but only a part of the hydrogen can be united with the sulphur in this mode of operating.

The usual way of preparing sulphuretted hydrogen, is to pour a dilute sulphuric or muriatic acid, on the black sulphuret of iron or antimony in a retort. For accurate experiments, it should be collected over mercury. It takes fire when a lighted taper is brought in contact with it, and burns with a pale blue flame, depositing sulphur. Its smell is extremely fetid, resembling that of rotten eggs. Its taste is sour. It reddens vegetable blues. It is absorbable by water, which takes more than an equal volume of the gas. Its sp. gr. according to MM. Gay-Lussac and Thenard, is to that of air, 1.1912 to 1.0. From Sir H. Davy's experiments, it would appear to be a little less, but he is inclined to adopt the results of the French chemists, rather than his own, as their gas was weighed in larger quantity, and dried. Notwithstanding this preference of other experiments to his own, we must prefer a number nearer to Sir H. Davy's than M. Gay-Lussac's. Its true sp. gr. is 1.1805. 100 cubic inches weigh 36.006 gr.; and it consists of 1 volume vapour of sulphur $= 1.1111. + 1$ volume of hydrogen $= 0.0694 = 1.1805$; or a prime equivalent of each $= 2.125$. If platina wires be ignited in it, by the voltaic apparatus, it is rapidly decomposed. Sulphur is deposited, and an equal volume of hydrogen remains. The same change is effected more slowly by the electric spark.

Of all the gases, sulphuretted hydrogen is perhaps the most deleterious to animal life. A greenfinch, plunged into air, which contains only $\frac{1}{1500}$ of its volume, perishes instantly. A dog of middle size is destroyed in air that contains $\frac{1}{800}$; and a horse would fall a victim to an atmosphere containing $\frac{1}{250}$.

Dr. Chaussier proves, that to kill an animal, it is sufficient to make the sulphuretted hydrogen gas act on the surface of its body, when it is absorbed by the inhalants. He took a bladder having a stop-cock at one end, and at the other an opening, into which he introduced the body of a rabbit, leaving its head outside, and securing the bladder air-tight round the neck by adhesive plaster. He then sucked the air out of the bladder, and replaced it by sulphuretted hydrogen gas. A young animal in these circumstances, usually perishes in in 15 or 20 minutes. Old rabbits resist the poison much longer.

When potassium or sodium is heated, merely to fusion, in contact with sulphuretted hydrogen, it becomes luminous, and burns with extrication of hydrogen, while a metallic sulphuret remains, combined with sulphuretted hydrogen, or a sulphuretted hydrosulphuret.

Sulphuretted hydrogen combines with an equal volume of ammonia; and unites to alkalis and oxides, so that it has all the characters of an acid. These compounds are called *hydrosulphurets.*

All the *hydrosulphurets,* soluble in water, have an acrid and bitter taste, and when in the liquid state, the odour of rotten eggs. All those which are insoluble, are, on the contrary, insipid and without smell. There are only two coloured hydrosulphurets, that of iron, which is black, and of antimony, which is chesnut-brown.

All the hydrosulphurets are decomposed by the action of fire. That of magnesia is transformed into sulphuretted hydrogen and oxide of magnesium; those of potash and soda, into sulphuretted hydrogen, hydrogen, and sulphuretted alkalis; those of manganese, zinc, iron, tin, and antimony, into water and metallic sulphurets.

When we put in contact with the air, at the ordinary temperature, an aqueous solution of a hydrosulphuret, there results, in the space of some days, 1st, water, and a sulphuretted hydrosulphuret, which is yellow and soluble; 2d, water, and a colourless hydrosulphite, which, if its base be potash, soda, or ammonia, remains in solution in the water; but which falls down in acicular crystals, if its base be barytes, strontia, or lime.

The acids in general combine with the base of the hydrosulphurets, and disengage sulphuretted hydrogen with a lively effervescence, without any deposition of sulphur, unless the acid be in excess, and be capable, like the nitric and nitrous acids, of yielding a portion of its oxygen to the hydrogen of the sulphuretted hydrogen.

The hydrosulphurets of potash, soda, ammonia, lime, and magnesia, are prepared directly, by transmitting an excess of sulphuretted hydrogen gas, through these bases, dissolved or diffused in water.

The composition of the hydrosulphurets is such, that the hydrogen of the sulphuretted hydrogen, is to the oxygen of the oxide in the same ratio as in water. Hence, when we calcine the hydrosulphurets of iron, tin, &c. we convert them into water and sulphurets.

Hydrosulphuret of potash crystallizes in four-sided prisms, terminated by four-sided pyramids. Its taste is acrid and bitter. Exposed to the air, it attracts humidity, absorbs oxygen, passes to the state of a sulphuretted hydrosulphuret, and finally to that of a hydrosulphite. It is extremely soluble in water. Its solution in this liquid occasions a perceptible refrigeration. Subjected to heat, it evolves much sulphuretted hydrogen, and the hydrosulphuret passes to the state of a sub-hydrosulphuret.

Hydrosulphuret of soda crystallizes with more difficulty than the preceding.

Hydrosulphuret of ammonia is obtained by the direct union of the two gaseous constituents in a glass balloon, at a low temperature. As soon as the gases mingle, transparent white or yellowish crystals are formed. When a mere solution of this hydrosulphuret is wished for medicine or analysis, we pass a current of sulphuretted hydrogen through aqueous ammonia till saturation.

The pure hydrosulphuret is white, transparent, and crystallized in needles or fine plates. It is very volatile. Hence, at ordinary temperatures, it gradually sublimes into the upper part of the phials in which we preserve it. We may also by the same means separate it from the yellow sulphuretted hydrosulphuret, with which it is occasionally mixed. When exposed to the air, it absorbs oxygen, passes to the state of a sulphuretted hydrosulphuret, and becomes yellow. When it contains an excess of ammonia, it dissolves speedily in water, with the production of a very considerable coal.

Sub-hydrosulphuret of barytes is prepared by dissolving, in five or six parts of boiling water, the sulphuret of the earth obtained by igniting the sulphate with charcoal. The solution, being filtered while hot, will deposite, on cooling, a multitude of crystals which must be drained, and speedily dried by pressure between the folds of blotting paper. It crystallizes in white scaly plates. It is much more soluble in hot than in cold water. Its solution is colourless, and capable of absorbing, at the ordinary temperature, a very large quantity of sulphuretted hydrogen.

Sub-hydrosulphuret of strontites crystallizes in the same manner as the preceding. The crystals obtained in the same way must be dissolved in water; and the solution being exposed to a stream of sulphuretted hydrogen, and then concentrated by evaporation in a retort, will afford, on cooling, crystals of pure sub-hydrosulphuret.

Hydrosulphurets of lime and magnesia have been obtained only in aqueous solutions. The metallic hydrosulphurets of any practical importance are treated of under their respective metals.

When we expose sulphur to the action of a solution of a hydrosulphuret, saturated with sulphuretted hydrogen, so much more sulphuretted hydrogen is evolved, as the temperature is more elevated. But when the solution of hydrosulphuret, instead of being saturated, has a sufficient excess of alkali, it evolves no perceptible quantity of sulphuretted hydrogen, even at a boiling heat; although it dissolves as much sulphur as in its state of saturation. It hence follows, 1st, That sulphuretted hydrogen, sulphur, and the alkalis, have the property of forming very variable triple combinations; 2d, That all these combinations contain less sulphuretted hydrogen than the hydrosulphurets; and, 3d, That the quantity of sulphuretted hydrogen is inversely as the sulphur they contain, and reciprocally. These compounds have been called, in general, sulphuretted hydrosulphurets; but the name of hydrogenated sulphurets is more particularly given to those combinations which are saturated with sulphur at a high temperature, because, by treating them with acids, we precipitate a peculiar compound of sulphur and hydrogen, of which we shall now treat.

This compound of hydrogen and sulphur, the proportions of the elements of which have not yet been accurately ascertained, is also called a hydruret of sulphur. It is formed by putting flowers of sulphur in contact with nascent sulphuretted hydrogen. With this view, we take an aqueous solution of the hydrogenated sulphuret of potash, and pour it gradually into liquid muriatic acid, which seizes the potash, and forms a soluble salt, whilst the sulphur and sulphuretted hydrogen unite, fall down together, collecting by degrees at the bottom of the vessel, as a dense oil does in water. To preserve this hydruret of sulphur, we must fill with it a phial having a ground stopper, cork it, and keep it inverted in a cool place. We may consider this substance either as a combination of sulphur and hydrogen, or of sulphur and sulphuretted hydrogen; but its properties, and the mode of obtaining it, render the latter the more probable opinion. The proportion of the constituents is not known.

The most interesting of the hydrogenated sulphurets is that of ammonia. It was discovered by the Hon. Robert Boyle, and called his fuming liquor. To prepare it, we take one part of muriate of ammonia and of pulverized quicklime, and half a part of flowers of sulphur. After mixing them intimately, we introduce the mixture into an earthen or glass retort, taking care that none of it remains in the neck. A dry cooled receiver is connected to the retort by means of a long adopter-tube. The heat must be urged slowly almost to redness. A yellowish liquor condenses in the receiver, which is to be put into a phial with its own weight of flowers of sulphur, and agitated with it seven or eight minutes. The greater part of the sulphur is dissolved, the colour of the mixture deepens remarkably, and becomes thick, constituting the hydrogenated sulphuret.

The distilled liquor diffuses, for a long time, dense vapour in a jar full of oxygen or common air; but scarcely any in azote or hydrogen; and the dryness or humidity of the gases makes no difference in the effects. It is probably owing to the oxygen converting the liquor into a hydrogenated sulphuret, or perhaps to the state of sulphite, that the vapours appear.

Hydrogenated sulphurets are frequently called hydroguretted sulphurets.

Sulphur combines with carbon, forming an interesting compound, to which the name of sulphuret of carbon is sometimes given. I have described it under the title CARBURET OF SULPHUR. For the combinations of sulphur and phosphorus, see the latter article.*

* SULPHURETTED CHYAZIC ACID. See ACID (SULPHURO-PRUSSIC).*

* SULPHURIC ACID. See ACID (SULPHURIC).*

* SULPHUROUS ACID. See ACID (SULPHUROUS).*

SUMACH. Common sumach (rhus coriaria) is a shrub that grows naturally in Syria, Palestine, Spain, and Portugal. In the two last, it is cultivated with great care. Its shoots are cut down every year quite to the root, and, after being dried, they are reduced to powder by a mill, and thus prepared for the purposes of dyeing and tanning. The sumach cultivated in the neighbourhood of Montpellier, is called *rédoul*, or *roudou*.

Mr. Hatchett found, that an ounce contains about 78 or 79 grains of tannin.

Sumach acts on a solution of silver just as galls do; it reduces the silver to its metallic state; and the reduction is favoured by the action of light.

Of all astringents sumach bears the greatest resemblance to galls. The precipitate, however, produced in solutions of iron by an infusion of it is less in quantity than what is obtained by an equal weight of galls; so that in most cases it may be substituted for galls, the price of which is considerable, provided we proportionally increase its quantity.

Sumach alone gives a fawn colour, inclining to green; but cotton stuffs, which have been impregnated with printer's mordant, that is, acetate of alumina, take a pretty good and very durable yellow. An inconvenience is experienced in employing sumach in this way, which arises from the fixed nature of its colour; the ground of the stuff does not lose its colour by exposure on the grass, so that it becomes necessary to impregnate all the stuff with different mordants, to vary the colours, without leaving any part of it white.

SUPERSALT. A compound of an acid and base, in which the acid is in excess. See SUBSALT.

* SURTURBRAND. Fibrous brown coal, or bituminous wood, so called in Iceland, where it occurs in great quantities.*

* SWAMP ORE. Indurated bog iron ore.*

SWEAT. When the temperature of the body is much increased, either by being exposed to a hot atmosphere, or by violent exercise, the perspired vapour not only increases in quantity, but even appears in a liquid form. This is known by the name of *sweat*.

Beside water, it cannot be doubted, that *carbon* is also emitted from the skin; but in what state, the experiments hitherto made do not enable us to decide. Mr. Cruickshanks found, that the air of the glass vessel in which his hand and foot had been confined for an hour, contained carbonic acid gas; for a candle burned dimly in it, and it rendered lime-water turbid. And Mr. Jurine found, that air which had remained for some time in contact with the skin, consisted almost entirely of carbonic acid gas. The same conclusion may be drawn from the experiments of Ingenhousz and Milly. Trousset has lately observed, that air was separated copiously from a patient of his while bathing.

Beside water and carbon, or carbonic acid gas, the skin emits also a particular odorous substance. That every aninal has a peculiar smell, is well known: the dog can discover his master, and even trace him to a distance by the scent. A dog, chained up several hours after his master had set out on a journey of some hundred miles, followed his footsteps by the smell. But it is needless to multiply instances of this fact, they are too well known to every one. Now this smell must be owing to some peculiar matter which is constantly emitted; and this matter must differ somewhat either in quantity or some other property, as we see, that the dog easily distinguishes the individual by means of it. Mr. Cruickshanks has made it probable that this matter is an oily substance; or at least, that there is an oily substance emitted by the skin. He wore repeatedly, night and day for a month, the same under waistcoat of fleecy hosiery, during the hottest part of the summer. At the end of this time he always found an oily substance accumulated in considerable masses on the nap of the inner surface of the waistcoat, in the form of black tears. When rubbed on paper, it rendered it transparent, and hardened on it like grease. It burned with a white flame, and left behind it a charry residuum.

Berthollet has observed the perspiration acid; and he has concluded, that the acid which is present is the phosphoric; but this has not been proved. Fourcroy and Vauquelin have ascertained, that the scurf which collects upon the skins of horses, consists chiefly of phosphate of lime, and urea is even sometimes mixed with it.

According to Thenard, however, who has lately endeavoured more particularly to ascertain this point, the acid contained in sweat is the acetous; which, he likewise observes, is the only free acid contained in urine and in milk, this acid existing in both of them when quite fresh. His account of his examination of it is as follows:

The sweat is more or less copious in different individuals; and its quantity is perceptibly in the inverse ratio of that of the urine. All other circumstances being similar, much more is produced during digestion than during repose. The maximum of its production appears to be twenty-six grains and two-thirds in a minute, the minimum nine grains troy weight. It is much inferior, however, to the pulmonary transpiration; and there is likewise a great difference between their nature and manner of formation. The one is the product of a particular secretion, similar in some sort to that of the urine; the other, composed of a great deal of water and carbonic acid, is the product of a combustion gradually effected by the atmospheric air.

The sweat, in a healthy state, very sensibly reddens litmus paper or infusion. In certain diseases, and particularly in putrid fevers, it is alkaline; yet its taste is always rather saline, and more similar to that of salt than acid. Though colourless, it stains linen. Its smell is peculiar, and insupportable when it is concentrated, which is the case in particular during distillation. But before he speaks of the trials to which he subjected it, and of which he had occasion for a great quantity, he describes the method he adopted for procuring it, which was similar to that of Mr. Cruickshanks.

Human sweat, according to M. Thenard, is formed of a great deal of water; free acetous acid; muriate of soda; an atom of phosphate of lime, and oxide of iron; and an inappreciable quantity of animal matter, which approaches much nearer to gelatin than to any other substance.

* **Swinestone.** A variety of compact lucullite, a sub-species of limestone.*

Sylvanite. Native tellurium.

Sylvius (Salt of), or (**Febrifuge Salt of**). Muriate of potash.

Synovia. Within the capsular ligament of the different joints of the body, there is contained a peculiar liquid, intended evidently to lubricate the parts, and to facilitate their motion. This liquid is known among anatomists by the name of *synovia*.

From the analysis of M. Margueron, it appears, that synovia is composed of the following ingredients:

11.86	fibrous matter
4.52	albumen
1.75	muriate of soda
.71	soda
.70	phosphate of lime
80.46	water
100.00	

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* **Tabular Spar, or Table Spar.** The schaalstein of Werner, and prismatic augite of Jameson.

Colour grayish-white. Massive, and in angular-granular concretions. Shining pearly. Cleavage double. Fracture splintery. Translucent. Harder than fluor spar, but not so hard as apatite. Brittle. Sp. gr. 3.2 to 3.5. Its constituents are, silica 50, lime 45, water 5.—*Klaproth.* It occurs in primitive rocks, at Orawicza in the Bannat of Temeswar, where it is associated with brown garnets.*

* **Tacamahac.** A resin, having the aroma of musk, and soluble in alcohol.*

* **Talc.** Of this mineral, Professor Jameson's sixth sub-species of rhomboidal mica, there are two kinds; common talc, and indurated talc.

1. *Common talc.* Colour greenish-white. Massive, disseminated, in plates, imitative, and sometimes crystallized in small six-sided tables, which are druses. Splendent, pearly, semi-metallic. Cleavage single, with curved folia. Translucent. Flexible, but not elastic. Yields to the nail. Perfectly sectile. Feels very greasy. Sp. gr. 2.77. It whitens, and at length affords a small globule of enamel, before the blowpipe. Its constituents are, silica 62, magnesia 27, alumina 1.5, oxide of iron 3.5, water 6.—*Vauquelin.* Klaproth found 2.75 of potash in 100 parts. It occurs in beds in mica-slate and clay-slate. It is found in Aberdeenshire, Banffshire, and Perthshire. The finest specimens come from Saltzburg, the Tyrol, and St. Gothard. It is an ingredient in rouge for the toilette, along with carmine and benzoin. This cosmetic communicates a remarkable degree of softness

to the skin, and is not injurious. The flesh polish is given to gypsum figures, by rubbing them with talc.

2. *Indurated talc*, or *talc-slate*. Colour greenish-gray. Massive. Fragments tabular. Translucent on the edges. Soft. Streak white. Rather sectile. Easily frangible. Not flexible. Feels greasy. Sp. gr. 2.7 to 2.8. It occurs in primitive mountains, where it forms beds in clay-slate and serpentine. It is found in Perthshire, Banffshire, the Shetland Islands, and abundantly on the Continent. It is employed for drawing lines by carpenters, tailors, hat-makers, and glaziers.—*Jameson.**

* TALCITE. Nacrite of Jameson, and earthy talc of Werner. Colour greenish-white. It consists of scaly parts. Glimmering, pearly. Friable. Feels very greasy. Soils. It melts easily before the blow-pipe. Its constituents are, alumina 81.75, magnesia 0.75, lime 4, potash 0.5, water 13.5. —*John*. This is a very rare mineral, occurring in veins, with sparry ironstone and galena, in the mining district of Freyberg.*

* TALLOW. See FAT.*

* TAMARINDS. The pulp consists, according to Vauquelin, of bitartrate of potash 300, gum 432, sugar 1152, jelly 576, citric acid 864, tartaric acid 144, malic acid 40, feculent matter 2880, water 3364; in 9752 parts.*

TANNIN. This, which is one of the immediate principles of vegetables, was first distinguished by Seguin from the gallic acid, with which it had been confounded under the name of the *astringent principle*. He gave it the name of tannin, from its use in the tanning of leather; which it effects by its characteristic property, that of forming with gelatin a tough insoluble matter.

It may be obtained from vegetables by macerating them in cold water; and precipitated from this solution, which contains likewise gallic acid and extractive matter, by hyperoxygenized muriate of tin. From this precipitate, immediately diffused in a large quantity of water, the oxide of tin may be separated by sulphuretted hydrogen gas, leaving the tannin in solution.

Professor Proust has since recommended another method, the precipitation of a decoction of galls by powdered carbonate of potash, washing well the greenish-gray flakes that fall down, with cold water, and drying them in a stove. The precipitate grows brown in the air, becomes brittle and shining like a resin, and yet remains soluble in hot water. The tannin in this state, he says, is very pure.

Sir H. Davy, after making several experiments on different methods of ascertaining the quantity of tannin in astringent infusions, prefers for this purpose, the common process of precipitating the tannin by gelatin; but he remarks, that the tannin of different vegetables requires different proportions of gelatin for its saturation; and that the quantity of precipitate obtained is influenced by the degree in which the solutions are concentrated.

M. Chenevix observed, that coffee berries acquired by roasting the property of precipitating gelatin; and Mr. Hatchett has made a number of experiments, which show, that an artificial tannin, or substance having its chief property, may be formed, by treating with nitric acid, matters containing charcoal. It is remarkable that this tannin, when prepared from vegetable substances, as dry charcoal of wood, yields, on combustion, products analogous to those of animal matters. From his experiments it would seem, that tannin is, in reality, carbonaceous matter combined with oxygen; and the difference in the proportion of oxygen may occasion the differences in the tannin procured from different substances, that from catechu appearing to contain most.

Bouillon Lagrange asserts, that tannin by absorbing oxygen is converted into gallic acid.

It is not an unfrequent practice, to administer medicines containing tannin in cases of debility, and at the same time to prescribe gelatinous food as nutritious. But this is evidently improper, as the tannin, from its chemical properties, must render the gelatin indigestible. For the chief use of tannin, see the following article.

* According to Berzelius, tannin consists of hydrogen 4.186 + carbon 51.160 + oxygen 44.654. And the tannate of lead is composed of

tannin,	100	26.923
oxide of lead,	52	14.

But there is much uncertainty concerning the definite neutrality of this compound.*

TANNING. The several kinds of leather are prepared from the skins of animals macerated for a long time with lime and water, to promote the separation of the hair and wool, and of the fat and fleshy parts, in which recourse is also had to the assistance of mechanical pressure, scraping, and the like. The skin, when thus deprived of its more putrescible part, and brought considerably toward the state of mere fibre, is tanned by maceration with certain astringent substances, particularly the bark of the oak-tree.

The hide consists almost wholly of gelatin, and all that is necessary is, to divest it of the hair, epidermis, and any flesh or fat adhering to it. This is commonly done, after they have been soaked in water some time, and handled or trodden to cleanse them from filth, by immersing them in milk of lime. Some, instead of lime, use an acescent infusion of barley or rye-meal, or spent tan; and others recommend water acidulated with sulphuric acid. Similar acidulous waters are afterward employed for raising or swelling the hide, when this is necessary.

The skins thus prepared, are finally to undergo what is properly called the tanning. This is usually done by throwing into a pit, or cistern made in the ground, a quantity of ground oak-bark, that has already been used, and on this the skins and fresh bark in alternate layers, covering the whole with half a foot of tan, and treading it well down. The tanning may be accelerated by adding a little water.

As it is a long time before the hide is thoroughly tanned in this mode, at least many months, during which the bark is renewed three or four times; M. Seguin steeps the skin in a strong infusion of tan, and assists its action by heat. Chaptal observes, however, that this requires an extensive apparatus, for preparing the liquor, and the skins: the leather imbibes so much water, that it remains spongy a long time, and wrinkles in drying; and it is extremely difficult so to arrange the hides in a copper, as to keep them apart from each other, and free of the sides of the vessel.

The following account of M. Seguin's practice, was transmitted to England in the year 1796:—

To tan a skin is to take away its putrescent quality, preserving, however, a certain degree of pliability. This is effected by incorporating with the skin particles of a substance, which destroys their tendency to putrefaction.

The operations relating to tanning are therefore of two kinds:—the first is merely depriving the skin of those parts, which would oppose its preservation, or which adhere to it but little, such as hair and flesh; the other consists in incorporating with it a substance, which shall prevent its putrefying.

The operations of the first kind are technically termed, unhairing and fleshing; the operations of the second kind belong to tanning, properly so called.

Fleshing is an operation merely mechanical: unhairing is a mechanical operation if performed by shaving; or a chemical operation, if effected by dissolution or decomposition of the substance, which connects the hair with the skin.

According to the ancient method, the dissolution of this substance was effected by means of lime; the decomposition, either by the vinous fermentation of barley, by the acetous fermentation of oak-bark, or by the putrid fermentation produced by piling the hides one upon another.

Unhairing by means of lime would often take 12 or 15 months; this operation with barley, or the acetous part of tan, could not be performed in less than two months. The slowness of these operations, which the experiments of Seguin have shown may be finished in a few days, and in a more advantageous manner, by means of the same substances, proves, that the nature of those operations was not understood by those who performed them. Those of tanning, properly so called, were as little known, as the details we are about giving will prove, which we compare with the least improved routine now in practice.

Whatever the method of unhairing was, the mode of tanning was always the same, for skins unhaired with lime, or those prepared with barley or tan.

This mode of operating would take eighteen months or two years, often three years, when it was wished to tan the hides thoroughly.

Among the substances for tanning, gall-nut, sumach, and the bark of oak, to which may be added catechu, appear the most proper, at least, in the present state of our knowledge. In the middle departments of France, oak-bark is preferred, because it is the cheapest and most abundant substance. To use it, it is first ground to powder; then, according to the old mode, it is put into large holes dug in the ground, which are filled by alternate layers of ground bark and unhaired hides.

As the principle which effects the tanning cannot act in the interior of the skin, unless carried in by some liquid in which it is first dissolved, tanning is not produced by the immediate action of the powdered bark upon the skin, but only by the action of the dissolution of the tanning principle originally contained in the bark. The tan therefore has the tanning property only when wetted so much as not to absorb all the water thrown on it. But as tanners put in their vats only a small portion of water compared to what would be necessary to deprive the bark of all the tanning principle which it contains, the bark put into the vats preserves, when taken out, a portion of its tanning principle.

This waste is not the only disadvantage of the old modes of proceeding; they are, besides, liable never to produce in the skins a complete saturation with the tanning principle. For as the property of attraction is common to all bodies, according to the different degree of saturation, the water containing in solution a certain quantity of the tanning principle, will not part, to a fixed weight of skins, with as much as the same quantity of water will, in which a greater quantity of the principle is dissolved.

As the water, which in the old manner of proceeding is in the vats, can contain but a small portion of the tanning principle, owing to the nature of the operation, it can give but a small portion of it to the skin, and even this it parts with by slow degrees. Hence, the slowness in the tanning of skins according to the old method, which required two whole years, and sometimes three, before a skin was well tanned to the centre. Hence also, the imperfection of skins tanned by that method; an imperfection resulting from the non-saturation of the tanning principle, even when it had penetrated the centre.

The important desideratum was, therefore, to get together, within a small compass, the tanning principle, to increase its action, and produce in the hide a complete saturation in a much shorter time than that necessary for the incomplete tanning produced in vats. But, first of all, it was necessary to analyze the skin, analyze the leather, and analyze the oak-bark. The principles of these three substances were to be insulated, and their action upon one another determined, the influence of their combination upon that action known, and the circumstances most productive of its greatest action found out.

Seguin, by following this method, has determined:—

1. That the skin deprived of flesh and hair, is a substance, which can easily, by a proper process, be entirely converted into an animal jelly (glue).

2. That a solution of this last mentioned substance, mixed with a solution of tan, forms immediately an imputrescible and indissoluble compound.

3. That the solution of tan is composed of two very distinct substances; one of which precipitates the solution of glue, and which is the true tanning substance; the other, which precipitates sulphate of iron, without precipitating the solution of glue, and which produces only the necessary disoxygenation of the skin, and of the substance which connects the hair to the skin.

4. That the operation of tanning is not a simple combination of the skin with the principle which precipitates the glue, but a combination of that principle with the skin disoxygenized by the substance, which in the dissolution of tan is found to precipitate the sulphate of iron; so that every substance proper for tanning should possess the properties of precipitating the solution of glue, and of precipitating the sulphate of iron.

5. That the operation of tanning consists in swelling the skins by means of an acidulous principle; to disoxygenize, by means of the principle which in the solution of bark precipitates the solution of sulphate of iron, that substance which connects the hair to the skin, and thus produce an easy unhairing; to disoxygenize the skin by means of the same principle, and to bring it by this disoxygenation to the middle state between glue and skin; and then to combine with it, after this disoxygenation, and while it is in this middle state, that particular substance in oak-bark, as well as in many other vegetables, which is found to precipitate the solution of glue, and which is not, as has been hitherto conceived, an astringent substance.

Agreeably to these discoveries, there only remains, in order to tan speedily and completely, to condense the tanning principle so as to accelerate its action. Seguin, to effect this, follows a very simple process. He pours water upon the powdered tan, contained in an apparatus nearly similar to that made use of in saltpetre works. This water, by going through the tan, takes from it a portion of its tanning principle, and by successive filtrations dissolves every time an additional quantity of it, till at last the bark rather tends to deprive it of some than to give up more. Seguin succeeds in bringing these solutions to such a degree of strength, that, he says, he can, by taking proper measure, tan calf-skin in 24 hours, and the strongest ox-hides in seven or eight days. These solutions containing a great quantity of the tanning principle, impart to the skin as much of it as it can absorb; so that it can then easily attain a complete saturation of the principle, and produce leather of a quality much superior to that of most countries famous for their leather.

On the above I have only to remark, that every new art or considerable improvement must unavoidably be attended with many difficulties in the establishment of a manufactory in the large way. From private inquiry I find, that this also has its difficulties, which have hitherto prevented its being carried into full effect in this country. Of what nature these may be I am not decidedly informed, and mention them in this place only to prevent manufacturers from engaging in an undertaking of this kind, without cautious inquiry.

M. Desmond has recommended, to saturate water with tannin, by affusion on successive portions of oak-bark, or whatever may be used; and when the bark will give out no more tannin, to extract what gallic acid still remains in it, by pouring on fresh water. To the latter, or acidulous liquor, he adds one-thousandth part by measure of sulphuric acid; and in this steeps the hide, till the hair will come off easily by scraping. When raising is necessary, he steeps the hide ten or twelve hours in water acidulated with a five-hundredth part by measure of sulphuric acid; after which they are to be washed repeatedly, and scraped with the round knife. Lastly, the hides are to be steeped some hours in a weak solution of tannin, then a few days in a stronger, and this must be renewed as the tannin is exhausted, till the leather is fully tanned.

For the softer skins, as calves', goats', &c. he does not use the acid mixture, but milk of lime.

Of substances used for tanning, Sir H. Davy observes, that 1 pound of catechu is nearly equal to 2½ of galls, 3 of sumach, 7½ of the bark of the Leicester willow, 8⅓ of oak-bark, 11 of the bark of the Spanish chestnut, 18 of elm-bark, and 21 of common willow-bark, with respect to the tannin contained in them. He observes too, that leather slowly tanned in weak infusions of barks appears to be better in quality, being both softer and stronger than when tanned by strong infusions; and he ascribes this to the extractive matter they imbibe. This principle, therefore, affects the quality of the material employed in tanning; and galls, which contain a great deal of tannin, make a hard leather, and liable to crack, from their deficiency of extractive matter.—*Ann. de Chim.*—*Philos. Trans.*—*Philos. Mag.*—*Chaptal's Chem.*

* **Tantalum Ore.** See Ore of Tantalum.*

* **Tantalum.** The metal already treated of under the name of Columbium.*

Tarras, or **Terras.** A volcanic earth used as a cement. It does not differ much in its principles from pouzzolana; but it is much more compact, hard, porous, and spongy. It is generally of a whitish-yellow colour, and contains more heterogeneous particles, as spar, quartz, schoerl, &c. and something more of a calcareous earth. It effervesces with acids, is magnetic, and fusible *per se.* When pulverized, it serves as a cement, like pouzzolana. It is found in Germany and Sweden. See Lime.

* **Tartar.** See Acid (Tartaric).*

Tartar is deposited on the sides of casks during the fermentation of wine: it forms a lining more or less thick, which is scraped off. This is called crude tartar, and is sold in Languedoc from 10 to 15 livres the quintal.

All wines do not afford the same quantity of tartar. Neumann remarked, that the Hungarian wines left only a thin stratum; that the wines of France afforded more; and that the Rhenish wines afforded the purest and the greatest quantity.

Tartar is distinguished from its colour into red and white: the first is afforded by red wine.

Tartar is purified from an abundant extractive principle, by processes which are executed at Montpellier and at Venice.

The following is the process used at Montpellier:—The tartar is dissolved in water, and suffered to crystallize by cooling. The crystals are then boiled in another vessel, with the addition of five or six pounds of the white argillaceous earth of Murveil to each quintal of the salt. After this boiling with the earth, a very white salt is obtained by evaporation, which is known by the name of cream of tartar, or the acidulous tartrate of potash.

M. Desmaretz has informed us, that the process used at Venice consists,

1. In drying the tartar in iron boilers.
2. Pounding it, and dissolving it in hot water, which, by cooling, affords purer crystals.
3. Redissolving these crystals in water, and clarifying the solution by whites of eggs and ashes.

The process of Montpellier is preferable to that of Venice. The addition of the ashes introduces a foreign salt, which alters the purity of the product. See Acid (Tartaric).

Tartar (Chalybeated). This is prepared by boiling three parts of the supertartrate of potash and two of iron filings in forty-six parts of water, till the tartar appears to be dissolved. The liquor is then filtered, and crystals are deposited on cooling, more of which are obtained by continuing the evaporation.

Tartar (Cream of). The popular name of the purified supertartrate of potash.

Tartar (Crude). The supertartrate of potash in its natural state, before it has been purified.

Tartar (Emetic). The tartrate of potash and antimony. See Antimony.

Tartar of the teeth. The popular name for the concretion that so frequently incrusts the teeth, and which consists apparently of phosphate of lime.

Tartar (Regenerated). Acetate of potash.

Tartar (Salt of). The subcarbonate of potash.

Tartar (Secret Foliated Earth of). Acetate of potash.

Tartar (Soluble). Neutral tartrate of potash.

Tartar (Vitriolated). Sulphate of potash.

Tartarine. The name given by Kirwan to the vegetable alkali, or potash.

Tartarous Acid. See Acid (Tartaric).

Tartrate. A neutral compound of the tartaric acid with a base.

Tears. That peculiar fluid, which is employed in lubricating the eye, and which is emitted in considerable quantities when we express grief by weeping, is known by the name of *tears.* For an accurate analysis of this fluid we are indebted to Messrs. Fourcroy and Vauquelin.

The liquid called tears is transparent and colourless like water; it has scarcely any smell, but its taste is always perceptibly salt. Its specific gravity is somewhat greater than that of distilled water. It gives to paper stained with the juice of the petals of mallows or violets as permanently green colour, and therefore contains a fixed alkali. It unites with water, whether cold or hot, in all proportions. Alkalis unite with it readily, and render it more fluid. The mineral acids produce no apparent change upon it. Exposed to the air, this liquid gradually evaporates, and becomes thicker. When nearly reduced to a state of dryness, a number of cubic crystals form in the midst of a kind of mucilage. These crystals possess the properties of muriate of soda; but they tinge vegetable blues green, and therefore contain an excess of soda. The mucilaginous matter acquires a yellowish colour as it dries.

Tears are composed of the following ingredients:—

1. Water,
2. Mucus,
3. Muriate of soda,
4. Soda,
5. Phosphate of lime,
6. Phosphate of soda.

The saline parts amount only to about 0.01 of the whole, or probably not so much.

Teeth. The basis of the substance that forms the teeth, like that of other bones, (See Bone), appears to be phosphate of lime. The enamel, however, according to Mr. Hatchett, differs from other bony substances in being destitute of cartilage: for raspings of enamel, when macerated in diluted acids, he found were wholly dissolved; while raspings of bone, treated in the same manner, always left a cartilaginous substance untouched. See Bone.

* **Telesia.** Sapphire.*

Tellurium. Muller first suspected the existence of a new metal in the aurum paradoxicum, or problematicum, which has the appearance of an ore of gold, though very little can be extracted from it. Klaproth afterward established its existence, not only in this, but in some other Transylvanian ores, and named it *tellurium*.

Pure tellurium is of a tin-white colour, verging to lead-gray, with a high metallic lustre; of a foliated fracture, and very brittle, so as to be easily pulverized. Its sp. gr. 6.115. It melts before ignition, requiring a little higher heat than lead, and less than antimony; and, according to Gmelin, is as volatile as arsenic. When cooled without agitation, its surface has a crystallized appearance. Before the blow-pipe on charcoal it burns with a vivid blue light, greenish on the edges; and is dissipated in grayish-white vapours, of a pungent smell, which condense into a white oxide. This oxide heated on charcoal is reduced with a kind of explosion, and soon again volatilized. Heated in a glass retort, it fuses into a straw-coloured striated mass. It appears to contain about 16 per cent of oxygen.

Tellurium is oxidized and dissolved by the principal acids. To sulphuric acid it gives a deep purple colour. Water separates it in black flocculi, and heat throws it down in a white precipitate.

With nitric acid it forms a colourless solution, which remains so when diluted, and affords slender dendritic crystals by evaporation.

The muriatic acid, with a small portion of nitric, forms a transparent solution, from which water throws down a white submuriate. This may be redissolved almost wholly by repeated affusions of water. Alcohol likewise precipitates it.

Sulphuric acid, diluted with two or three parts of water, to which a little nitric acid has been added, dissolves a large portion of the metal, and the solution is not decomposed by water.

The alkalis throw down from its solutions a white precipitate, which is soluble in all the acids, and by an excess of the alkalis or their carbonates. They are not precipitated by prussiate of potash. Tincture of galls gives a yellow flocculent precipitate with them. Tellurium is precipitated from them in a metallic state by zinc, iron, tin, and antimony.

Tellurium fused with an equal weight of sulphur, in a gentle heat, forms a lead-coloured striated sulphuret. Alkaline sulphurets precipitate it from its solutions of a brown or black colour. In this precipitate either the metal or its oxide is combined with sulphur. Each of these sulphurets burns with a pale blue flame, and white smoke. Heated in a retort, part of the sulphur is sublimed, carrying up a little of the metal with it. It does not easily amalgamate with quicksilver.

* **Telluretted Hydrogen.** Tellurium and hydrogen combine to form a gas, called *telluretted hydrogen.* To make this compound, hydrate of potash, and oxide of tellurium are ignited with charcoal, and the mixture acted on by dilute sulphuric acid, in a retort connected with a mercurial pneumatic apparatus. An elastic fluid is generated, consisting of hydrogen holding tellurium in solution. It is possessed of very singular properties. It is soluble in water, and forms a claret-coloured solution. It combines with the alkalis. It burns with a bluish flame, depositing oxide of tellurium. Its smell is very strong and peculiar, not unlike that of sulphuretted hydrogen. This elastic fluid was discovered by Sir H. Davy in 1809. When tellurium is made the electrical negative surface in water in the voltaic circuit, a brown powder is formed, which appears

to be a solid combination of hydrogen and tellurium. It was first observed by Mr. Ritter in 1808. The composition of the gas and the solid hydruret has not been ascertained. The prime equivalent of tellurium according to Sir H. Davy, is 4.93, reduced to the oxygen radix. Berzelius makes the oxide of tellurium a compound of metal 100 + oxygen 24.8. If we call the oxygen 25, then the atom or prime would be 4. In this case, telluretted hydrogen, if analogous in its constitution to sulphuretted hydrogen, would have a sp. gr. of 2.2916, (not 2.3074, as Dr. Thomson deduces it from the very same *data*).*

*TEMPERATURE. A definite term of sensible heat, as measured by the thermometer. Thus we say a high temperature, and a low temperature, to denote a manifest intensity of heat or cold; the temperature of boiling water, or 212° Fahr.; and a range of temperature, to designate the intermediate points of heat between two distant terms of thermometric indication. According to M. Biot, *temperatures* are the different energies of caloric, in different circumstances.

The general doctrines of caloric have been already fully treated of under the articles *Caloric*, *Combustion*, *Congelation*, *Climate*, and *Pyrometer*.

The changes induced on matter, at different temperatures, relate either to its magnitude, form, or composition. The first two of these effects are considered under *Expansion*, *Concreting Temperatures*, and *Pyrometer*; the third under *Combustion*, and the *Individual Chemical Bodies*. I shall here introduce some facts concerning the temperature of living bodies, and that of our northern climates, as modified by the constitution of water.

The power which man possesses of resisting the impression of external cold is well known, and fully exemplified in high latitudes. That of sustaining high heats has been made the subject of experiment. On the continent, the girls who are sent into ovens often endure for a short period a heat of 300° F. and upwards. If the skin be covered with varnish, which obstructs the perspiration, such heats, however, become intolerable. Dr. Fordyce staid for a considerable time, and without great inconvenience, in a room heated by stoves to 260° of Fahrenheit's scale. The lock of the door, his watch and keys, lying on the table, could not be touched without burning his hand. An egg became hard; and though his pulse beat 139 times per minute, yet a thermometer held in his mouth was only 2° or 3° hotter than ordinary. He perspired most profusely.—*Phil. Trans.* vol. 64 and 65.

It has been shown under *Caloric*, that fresh water possesses a maximum density about 39½° F. When its temperature deviates from this point, either upwards or downwards, its density diminishes, or its volume enlarges, Hence, when the intensely cold air from the circumpolar regions, presses southwards, after the autumnal equinox, it progressively abstracts the heat from the great natural basins of water or lakes, till the temperature of the whole aqueous mass sinks to 39½°. At this term, the refrigerating influence of the atmosphere, incumbent on the water, becomes nearly null. For, as the superficial stratum, by farther cooling, becomes specifically lighter, it remains on the surface, and soon becomes a cake of ice, which being an imperfect conductor of heat, screens the subjacent liquid water from the cold air. Had water resembled mercury, oils, and other liquids, in continuing to contract in volume, by cooling, till its congelation commenced, then the incumbent cold air would have robbed the mass of water in a lake, of its caloric of fluidity, by unceasing precipitation of the cold particles to the bottom, till the whole sunk to 32°. Then the water at the bottom, as well as that above, would have begun to solidify, and in the course of a severe winter in these latitudes, a deep lake would have become throughout a body of ice, never again to be liquefied. We can easily see, that such frozen masses would have acted as centres of baleful refrigeration to the surrounding country; and that under such a disposition of things, Great Britain must have been another Lapland. Nothing illustrates more strikingly the beneficent economy of Providence, than this peculiarity in the constitution of water, or anomaly, as it has been rather preposterously termed. What seems void of law to short-sighted man, is often, as in the present case, the finest symmetry and truest order.*

TENACITY. See COHESION.

*TENNANTITE. Colour, from lead-gray to iron-black. Massive, but usually crystallized, in rhomboidal dodecahedrons, cubes, or octahedrons. Splendent, and tin-white; occasionally dull. Cleavage dodecahedral. Streak reddish-gray. Rather harder than gray copper. Brittle. Sp. gr. 4.375. It yields a blue flame followed by arsenical vapours; and leaves a magnetical scoria. Its constituents are copper 45.32, sulphur 28.74, arsenic 11.84, iron 9.26, silica 5.—*Richard Phillips*. It occurs in Cornwall in copper veins that intersect granite and clay-slate, associated with common copper pyrites. It is a variety of gray copper.*

TERRA PONDEROSA. See HEAVY SPAR and BARYTES.

TERRA JAPONICA. Catechu.

TERRA LEMNIA.. A red bolar earth formerly esteemed in medicine. See LEMNIAN EARTH.

Terra Sienna. A brown bole or ochre, with an orange cast, brought from Sienna in Italy, and used in painting, both raw and burnt. When burnt it becomes of a darker brown. It resists the fire a long time without fusing. It adheres to the tongue very forcibly.

Terre Verte. This is used as a pigment, and contains iron in some unknown state, mixed with clay, and sometimes with chalk and pyrites.

* **Thallite.** Epidote or Pistacite.*

* **Thermometer.** An instrument for measuring heat, founded on the principle, that the expansions of matter are proportional to the augmentations of temperature. With regard to aëriform bodies, this principle is probably well founded; and hence, our common thermometers may be rendered just, by reducing their indications to those of an air thermometer. Solids, and still more liquids, expand unequally, by equal increments of heat, or intervals of temperature. With regard to water, alcohol, and oils, this inequality is so considerable as to occasion their rejection, for purposes of exact thermometry. But we have shown that mercury approaches more to metals than ordinary liquids, in its rate of expansion, and hence, as well as from its remaining liquid through a long range of temperature, it is justly preferred to the above substances for thermometric purposes. A common thermometer, therefore, is merely a vessel in which very minute expansions of mercury may be rendered perceptible; and, by certain rules of graduation, be compared with expansions made on the same liquid by other observers. The first condition is fulfilled by connecting a narrow glass tube with a bulb of considerable capacity, filled with quicksilver. As this fluid metal expands 1-63d by being heated in glass vessels, from the melting point of ice to the boiling point of water, if 10 inches of the tube have a capacity equal to 1-63d of that of the bulb, it is evident that, should the liquid stand at the beginning of the tube, at 32°, it will rise up and occupy ten inches of it at 212°. Hence, if the tube be uniform in its calibre, and the above space be divided into equal parts by an attached scale, then we shall have a centigrade or Fahrenheit's thermometer, according as the divisions are 100 or 180 in number. Such are the general principles of thermometric construction. But to make an exact instrument, more minute investigation is required.

The tubes drawn at glass-houses for making thermometers, are all more or less irregular in the bore, and for the most part conical. Hence, if equal apparent expansions of the included mercury be taken to represent equal thermometric intervals, these equal expansions will occupy unequal spaces in an irregular tube. The attached scale should therefore correspond exactly to these tubular inequalities; or if the scale be uniform in its divisions, we must be certain that the tube is absolutely uniform in its calibre. I may join the authority of Mr. Troughton's opinion to my own for affirming, that a tube of a truly equable bore is seldom or never to be met with. Hence we should never construct our thermometers on that supposition.

The first step in the formation of this instrument, therefore, is to graduate the tube into spaces of equal capacity. A small caoutchouc bag with a stop-cock and nozzle capable of admitting the end of the glass tube, when it is wrapped round with a few folds of tissue paper, must be provided, as also pure mercury and a sensible balance. Having expelled a little air from the bag, we dip the end of the attached glass tube into the mercury, and by the elastic expansion of the caoutchouc; we cause a small portion of the liquid to rise into the bore. We then shut the stop-cock, place the tube in a horizontal direction, and remove it from the bag. The column of mercury should not exceed half an inch in length. By gently inclining the tube, and tapping it with our finger, we bring the mercury to about a couple of inches from the end where we mean to make the bulb, and, with a file or diamond, mark there the initial line of the scale. The slip of ivory, brass, or paper, destined to receive the graduations, being laid on a table, we apply the tube to it, so that the bottom of the column of mercury coincides with its lower edge. With a fine point we then mark on the scale the other extremity of the mercurial column. Inclining the tube gently, and tapping it we cause the liquid to flow along till its lower end is placed where the upper previously stood. We apply the tube to the scale, taking care to make its initial line correspond to the edge as before. A new point for measuring equal capacity is now obtained. We thus proceed till the requisite length be graduated; and we then weigh the mercury with minute precision.

The bulb is next formed at the enameller's blow-pipe in the usual way. One of a cylindrical or conical shape, is preferable to a sphere, both for strengh and sensibility. We now ascertain, and note down its weight. A tubular coil of paper is to be tied to the mouth of the tube, rising in a funnel form an inch or two above it. Into this we pour recently boiled mercury, and applying the gentle heat of a lamp to the bulb, we expel a portion of the air. On allowing the bulb to cool, a portion of the mercury will descend into it, corresponding to the quantity of air previously expelled. The bulb is now to be heated over the lamp till the included mercury boil briskly for some time. On removing it the quicksilver will descend from the paper funnel, and completely fill the bulb and stem. Should any vesicle of air appear, the process of heating or boiling must be repeated, with the precaution of keeping a column of superincumbent mercury in the paper funnel. When the temperature of the bulb has sunk to nearly that of boiling water, it may be immersed in melting ice. The funnel and its mercury are then to be removed, and the bulb is to be plunged into boiling water. About 1-63d of the included mercury will now be expelled. On cooling the instrument again in melting ice, the zero point of the centigrade scale, corresponding to 32° of Fahrenheit, will be indicated by the top of the mercurial column. This point must be noted with a scratch on the glass, or else by a mark on the prepared scale. We then weigh the whole.

We have now sufficient data for completing the graduation of the instrument from *one* fixed point; and in hot climates, and other situations, where ice, for example, cannot be conveniently procured, this facility of forming an exact thermometer is important, We know the weight of the whole included mercury, and that of each *gradus* of the stem. And as from 32° to 212° F. or from 0° to 100° cent. corresponds to a mercurial expansion in glass of 1-63d, we can easily compute how many of our graduating spaces are contained in the range of temperature between freezing and boiling water. Thus, supposing the mercurial contents to be 378 grains, 1-63d of that quantity, or 6 grains, correspond to 180 of Fahrenheit's degrees. Now, if the initial measuring column were 0.6 of a grain, then 10 of these spaces would comprehend the range between freezing and boiling water. Hence, if we know the boiling point, we can set off the freezing point; or, from the temperature of the living body, 98° F., we can set off both the freeing and boiling points of water. In the present case, we must divide each space on our prepared scale into 18 equal parts, which would constitute degrees of Fahrenheit; or into 10 equal parts, which would constitute centigrade degrees; or into 8, which would form Reaumur's degrees. I have graduated thermometers in this way, and have found them to be very correct. When we have ice and boiling water at our command, however, we may dispense with the weighing processes. By plunging the instrument into melting ice, and then into boiling water, we find how many of our initial spaces on the stem correspond to that interval of temperature, and we subdivide them accordingly. If the tube be very unequable, we must accommodate even our subdivivisions to its irregularities, for which purpose the eye is a sufficient guide.

Thermometers are used for two different purposes, each of which requires peculiar adaptation. Thôse employed in meteorology, or for indicating atmospherical temperature, are wholly plunged in the fluid, and hence the stem as well as bulb are equally affected by the calorific energy. But when the chemist wishes to ascertain the temperature of corrosive liquids, or bland liquids highly heated, he can immerse merely the bulb, and the naked part of the stem under the scale. The portion of the tube corresponding to the scale, is not influenced by the heat, as in the former case; and hence, 1-63d part of the mercury, which at 32° F. was acted on, has at 212° escaped from its influence. (MM. Dulong and Petit make it 1-64.8th between 32° and 212°; see CALORIC). Hence I conceive, that a meteorological and a chemical thermometer ought to be graduated under the peculiar conditions in which they are afterwards to be used. The former should have its stem surrounded with the steam of boiling water, while its bulb is immersed an inch or two beneath the surface of that liquid, the barometer having at the time an altitude of 30 inches.

For ascertaining the boiling point on a thermometer stem, I adapt to the mouth of a tea-kettle a cylinder of tin-plate, the top of which contains a perforated cork. Through this, the glass tube can be slid to any convenient point; while the tin cylinder may also be raised or lowered, till the bulb rest an inch beneath the water. The nozzle of the kettle is shut with a cork; and at the top of the cylinder, a side-hole for escape of the steam is left. If the barometer differs from 30, by one inch, then the boiling point of water will differ by 1.92° F. Or 1° F. by Mr. Wollaston, corresponds to a difference of 0.589 of barometric pressure. When the barometer, for example, stands at 29 inches, water boils at 210.08 F.; and when it stands at 31 inches, the boiling temperature is 213.92. Particular attention must be paid to this source of variation.

A thermometer for chemical experiments should have its boiling point determined, by immersion only of the bulb and the naked portion of its stem below the scale, in boiling water. It is surely needless to say, that the water ought to be pure, since the presence of saline matter affects its boiling temperature; and it ought to be contained in a metallic vessel.

Before sealing up the end of the tube, we should draw it into a capillary point, and heat the bulb till the mercury occupy the whole of the stem. A touch of the blow-pipe flame on the capillary glass will instantly close it, and exclude the air from re-entering when the bulb becomes cool. If this has been skilfully executed, the column of mercury will move rapidly from one end of the tube to the other, when it is inverted, with a jerk. An ivory scale is the handsomest, but the most expensive. Those used in Paris consist of a narrow slip of paper, enclosed in a glass tube, which is attached in a parallel direction to the thermometer stem. It is soldered to it above, by the lamp, and hooked to it below, by a ring of glass. Such instruments are very convenient for corrosive liquids; and I find them not difficult to construct.

In treating of the measure of temperature under Caloric, I have endeavoured to show, that were the whole body of the thermometer, stem and bulb, immersed in boiling mercury, it would indicate 35° more than it does on the supposition of the bulb alone being subjected to the calorific influence, as takes place in common experiments. But MM. Dulong and Petit state, that it ought to indicate 680° in the former case, while Mr. Crichton shows that it actually indicates 656° in the latter, giving a difference of only 24° instead of 35°. This discordance between fact and theory, is only apparent; for we must recollect, that mercury being an excellent conductor of heat, will communicate a portion of that expansive energy from the immersed bulb, to the mercury in the stem, which will be retained, in consequence of glass being a very imperfect conductor of heat. Hence we may infer, that but for this communication of heat to the stem, a thermometer, whose bulb alone is plunged in boiling mercury, would stand at 645° F. or 17° below the true boiling temperature by an air thermometer, according to MM. Dulong and Petit. If we take the mean apparent expansion of mercury in glass, for 180°, between 32° and 662°, as given by these chemists, at 1-64th; then the above reduction would become 34.4° instead of 35°, an inconsiderable difference.

In consequence of this double compensation, a good mercurial thermometer, as constructed by Crichton, becomes an almost exact measure of temperature, or of the relative apparent energies of caloric.

At the end of the Dictionary, a table of reduction is given for the three thermometric scales, at present used in Europe; that of Reaumur, Celsius, or the centigrade, and Fahrenheit. The process of reduction is however a very simple case of arithmetic. To convert the centigrade interval into the Fahrenheit, we multiply by 1.8 or by 6 and 0.3, marking off the last figure of the product as a decimal. Thus an interval of 17° centigrade $= 17° \times 6 \times 0.3 =$ one of 30.6° Fahrenheit. But as the former scale marks the melting of ice 0° and the latter 32°, we must add 32° to 30.6° to have the Fahrenheit number = 62.6°.

Another form of the same rule of conversion is, from double the centigrade interval, subtract one-fifth, the remainder is the Fahrenheit interval. Thus from the double of $17° = 34°$, subtract $\frac{17}{5} = 3.4$, the remainder 30.6 is the corresponding interval on Fahrenheit's scale. To convert the Fahrenheit intervals into the centigrade, divide by 6 and by 0.3, and mark off the decimal point; thus: $95°.\ \mathrm{F.} = \frac{95°}{6 \times 0.3} = 52.77°\ \mathrm{C.}$

When we wish to reduce a Fahrenheit number to a centigrade, we must begin by deducting the 32° which the former is in advance, over the latter, at the melting of ice, or zero of the French scale. Thus to convert 95° Fahrenheit to the centigrade scale; $95° - 32° = 63°$; $\frac{63°}{6 \times 0.3} = 35°\ \mathrm{C.}$

All versed in arithmetical reduction, know how advantageous it is to confine it if possible to one rule, and not to blend two or more. Hence the ordinary rule of multiplying by 9, and dividing by 5, to bring the Fahrenheit to the centigrade intervals, seems less convenient than the preceding. With regard to the Reaumur scale, however, which is now of rare occurrence, we may employ the usual proportion of 9 to 4, or to the double add one-fourth.

F. = 9-4ths R. and
R. = 4-9ths F.

These are the relations of the intervals.

We must, however, attend to the initial 32° of Fahrenheit.

$$C° = \frac{F° - 32°}{6 \times 0.3}$$

$$F° = (C° \times 6 \times 0.3) + 32°$$

$$R° = \frac{4\,(F° - 32°)}{9}$$

$$F° = \tfrac{9}{4}\,R° + 32°$$

$$C° = \frac{R°}{0.8}$$

$$R° = 0.8 \times C°.$$

In the 15th volume of the Phil. Magazine, Mr. Crichton of Glasgow has described a self-registering thermometer of his invention, consisting of two oblong slips of steel and zinc, firmly fixed together by their faces; so that the greater expansion or contraction of the zinc, over those of the steel, by the same variations of temperature, causes a flexure of the compound bar. As this is secured to a board at one end, the whole flexure is exercised at the other, on the short arm of a lever index, the free extremity of which moves along a graduated arc. The instrument is originally adjusted on a good mercurial thermometer; and the movements of the arm are registered by two fine wires, which are pushed before it, and left at the maximum deviation to the right or left of the last observed position or temperature. The principle is obviously that of Arnold's compensation balance for chronometers.

An exquisite instrument on the same principle has been invented by M. Breguet, member of the academy of sciences, and board of longitude of France. It consists of a narrow metallic slip, about $\frac{1}{100}$ of an inch thick, composed of silver and platina, soldered together; and it is coiled in a cylindrical form. The top of this spiral tube is suspended by a brass arm, and the bottom carries, in a horizontal position, a very delicate golden needle, which traverses as an index, on a graduated circular plate. A steel stud, rises in the centre of the tube, to prevent its oscillations from the central position. If the silver be on the outside of the spiral, then the influence of increased temperature will increase the curvature, and move the appended needle in the direction of the coil; while the action of cold will relax the coil, and move the needle in the opposite direction. M. Breguet was so good as present me with two instruments; both of which are perfect thermometers, but one is the most sensible which I ever saw. For some details concerning it, see CALORIC. Dr. Wollaston showed me in 1809 a slip of copper coated with platinum, which exhibited by its curvature, over flame, or the vapour of water, the expanding influence of heat, in a striking manner. For other facts concerning the measurement of heat, see CALORIC.*

*THORINA. An earth discovered in 1816 by M. Berzelius. He found it in small quantities in the gadolinite of Korarvet, and two new minerals which he calls the deutofluate of cerium and the double fluate of cerium and yttria. It resembles zirconia.

To obtain it from those minerals that contain protoxide of cerium and yttria, we must first separate the oxide of iron by succinate of ammonia. The new earth, indeed, may, when alone, be precipitated by the succinates; but in the analytical experiments in which he has obtained it, it precipitated in so small a quantity along with iron, that he could not separate it from that oxide. The deutoxide of cerium is then precipitated by the sulphate of potash; after which the yttria and the new earth are precipitated together by caustic ammonia. Dissolve them in muriatic acid. Evaporate the solution to dryness, and pour boiling water on the residue, which will dissolve the greatest part of the yttria; but the undissolved residue still contains a portion of it. Dissolve it in muriatic or nitric acid, and evaporate it till it becomes as exactly neutral as possible. Then pour water upon it, and boil it for an instant. The new earth is precipitated, and the liquid contains disengaged acid. By saturating this liquid, and boiling it a second time, we obtain a new precipitate of the new earth.

This earth, when separated by the filter, has the appearance of a gelatinous, semitransparent mass. When washed and dried, it becomes white, absorbs carbonic acid, and dissolves with effervescence in acids. Though calcined, it retains its white colour; and when the heat to which it has been exposed was only moderate, it dissolves readily in muriatic acid; but if the heat has been violent, it will not dissolve till it be digested in strong muriatic acid. This solution has a yellowish colour; but it becomes colourless when diluted with water, as is the case with glucina, yttria, and alumina. If it be mixed with yttria, it dissolves more readily after having been exposed to heat. The neutral solutions of this earth have a purely astringent taste, which is neither sweet, nor saline, nor bitter, nor metallic. In this property it differs from all other species of earths, except zirconia.

When dissolved in sulphuric acid with a slight excess of acid, and subjected to evaporation, it yields transparent crystals, which are not altered by exposure to the air, and which have a strong styptic taste.

This earth dissolves very easily in nitric acid; but, after being heated to redness, it does not dissolve in it except by long boiling. The solution does not crystallize, but forms a mucilaginous mass, which becomes more liquid by exposure to the air, and which, when evaporated by a moderate heat, leaves a white, opaque mass, similar to enamel, in a great measure insoluble in water.

It dissolves in muriatic acid, in the same manner as in nitric acid. The solution does not crystallize. When evaporated by a moderate heat, it is converted into a sirupy mass, which does not deliquesce in the air, but dries, becomes white like enamel, and afterwards dissolves only in very small quantity in water, leaving a subsalt undissolved; so that by spontaneous evaporation it lets the portion of muriatic acid escape to which it owed its solubility.

This earth combines with avidity with carbonic acid. The precipitates produced by caustic ammonia, or by boiling the neutral solutions of the earth in acids, absorb carbonic acid from the air in drying. The alkaline carbonates precipitate the earth combined with the whole of their carbonic acid.

The ferruginous prussiate of potash, poured into a solution of this earth, throws down a white precipitate, which is completely re-dissolved by muriatic acid.

Caustic potash and ammonia have no action on this earth newly precipitated, not even at a boiling temperature.

The solution of carbonate of potash, or carbonate of ammonia, dissolves a small quantity of it, which precipitates again when the liquid is supersaturated with an acid, and then neutralized by caustic ammonia; but this earth is much less soluble in the alkaline carbonates than any of the earths formerly known that dissolve in them.

Thorina differs from the other earths by the following properties: From alumina by its insolubility in hydrate of potash; from glucina, by the same property; from yttria, by its purely astringent taste, without any sweetness, and by the property which its solutions possess of being precipitated by boiling when they do not contain too great an excess of acid. It differs from zirconia by the following properties: 1. After being heated to redness, it is still capable of being dissolved in acids. 2. Sulphate of potash does not precipitate it from its solutions while it precipitates zirconia from solutions containing even a considerable excess of acid. 3. It is precipitated by oxalate of ammonia, which is not the case with zirconia. 4. Sulphate of thorina crystallizes readily, while sulphate of zirconia, supposing it free from alkali, forms, when dried, a gelatinous, transparent mass, without any trace of crystallization.*

* **THORINUM.** The supposed metallic basis of the preceding earth, not hitherto extracted.*

* **THULITE.** A hard peach-blossom coloured mineral found at Sonland, in Tellemark in Norway.*

* **THUMERSTONE.** Axinite.*

* **TILE ORE.** A sub-species of octohedral red copper ore.*

TIN is a metal of a yellowish-white colour, considerably harder than lead, scarcely at all sonorous, very malleable, though not very tenacious. Under the hammer it is extended into leaves, called tin-foil, which are about one-thousandth of an inch thick, and might easily be beaten to less than half that thickness, if the purposes of trade required it. The process for making tin-foil consists simply in hammering out a number of plates of this metal, laid together upon a smooth block or plate of iron. The smallest sheets are the thinnest. Its specific gravity is 7.29. It melts at about the 442° of Fahrenheit's thermometer, and by a continuance of the heat it is slowly converted into a white powder by oxidation. Like lead, it is brittle when heated almost to fusion, and exhibits a grained or fibrous texture, if broken by the blow of a hammer; it may also be granulated by agitation at the time of its transition from the fluid to the solid state. The oxide of tin resists fusion more strongly than that of any other metal; from which property it is useful, to form an opaque white enamel when mixed with pure glass in fusion. The brightness of its surface, when scraped, soon goes off by exposure to the air; but it is not subject to rust or corrosion by exposure to the weather.

* To obtain pure tin, the metal should be boiled in nitric acid, and the oxide which falls down reduced by heat, in contact with charcoal, in a covered crucible.

There are two definite combinations of tin and oxygen. The first or protoxide is gray; the second or peroxide is white. The first is formed by heating tin in the air, or by dissolving tin in muriatic acid, and adding water of potash to the solution whilst recent, and before it has been exposed to air. The precipitate, after being heated to whiteness to expel the water of the hydrate is the pure protoxide. It is convertible into the peroxide by being boiled with dilute nitric acid, dried and ignited. According to Sir H. Davy, the protoxide contains 13.5 per cent of oxygen. Supposing it to consist of a prime equivalent of each constituent, that of tin would be 7.333. From the analyses of Berzelius and Gay-Lussac, the peroxide is composed of 100 metal + 27.2 oxygen; and if we regard it as containing 2 primes of the latter principle to 1 of metal, the prime of this will be 7.353. The mean may be taken at 7.35.

There are also two *chlorides* of tin. When tin is burned in chlorine, a very volatile clear liquor is formed, a non-conductor of electricity, and which when mixed with a little water, becomes a solid crystalline substance, a true muriate of tin, containing the peroxide of the metal. This, which has been called the liquor of Libavius, may be also procured, by heating together tin-filings and corrosive sublimate, or an amalgam of tin and corrosive sublimate. It consists, according to the analysis of Dr. John Davy, of 2 primes of chlorine = 9 + 1 of tin = 7.35. The other compound of tin and chorine, is a gray semi-transparent crystalline solid. It may be procured by heating together an amalgam of tin and calomel. It dissolves in water, and forms a solution which rapidly absorbs oxygen from the air with deposition of peroxide of tin. It consists of

Chlorine,	4.5
Tin,	7.35

There are two sulphurets of tin. One may be made by fusing tin and sulphur together. It is of a bluish colour, and lamellated texture. It consists of 7.35 tin + 2 sulphur. The other sulphuret, or the bisulphuret, is made by heating together the peroxide of tin and sulphur. It is of a

beautiful gold colour, and appears in fine flakes. It was formerly called *aurum musivum*. According to Dr. John Davy, it consists of 1 prime tin = 7.35
2 sulphur = 4.00
For another mode of making it, see Aurum Musivum.

The salts of tin are characterized by the following general properties:

1. Ferroprussiate of potash gives a white precipitate.
2. Hydrosulphuret of potash, a brown-black with the protoxide; and a golden-yellow with the peroxide.
3. Galls do not affect the solutions of these salts.
4. Corrosive sublimate occasions a black precipitate with the protoxide salts; a white with the peroxide.
5. A plate of lead frequently throws down metallic tin or its oxide, from the saline solutions.
6. Muriate of gold gives, with the protoxide solutions, the purple precipitate of Cassius.
7. Muriate of platinum occasions an orange precipitate with the protoxide salts.*

Concentrated sulphuric acid, assisted by heat, dissolves half its weight of tin, at the same time that sulphureous gas escapes in great plenty. By the addition of water, an oxide of tin is precipitated. Sulphuric acid, slightly diluted, likewise acts upon this metal; but if much water be present, the solution does not take place. In the sulphuric solution of tin, there is an actual formation or extrication of sulphur, which renders the fluid of a brown colour while it continues heated, but subsides by cooling. The tin is likewise precipitated in the form of a white oxide, by a continuance of the heat, or by long standing without heat. This solution affords needle-formed crystals by cooling.

Nitric acid and tin combine together very rapidly, without the assistance of heat. Most of the metal falls down in the form of a white oxide, extremely difficult of reduction; and the small portion of tin, which remains suspended, does not afford crystals, but falls down, for the most part, upon the application of heat to inspissate the fluid. The strong action of the nitric acid upon tin, produces a singular phenomenon, which is happily accounted for by the modern discoveries in chemistry. M. de Morveau has observed, that in a solution of tin by the nitric acid, no elastic fluid is disengaged, but ammonia is formed. This alkali must have been produced by the nitrogen of that part of the nitric acid which was employed in affording oxygen to oxidize the tin.

The muriatic acid dissolves tin very readily, at the same time that it becomes of a darker colour, and ceases to emit fumes. A slight effervescence takes place with the disengagement of a fetid inflammable gas. Muriatic acid suspends half its weight of tin, and does not let it fall by repose. It affords permanent crystals by evaporation. If the tin contain arsenic, it remains undissolved at the bottom of the fluid. Recent muriate of tin is a very delicate test of mercury. M. Chenevix says, if a single drop of a saturated solution of neutralized nitrate, or muriate of mercury, be put into 500 grains of water, a few drops of a solution of muriate of tin will render it a little turbid, and of a smoke-gray. He adds, that the effect is perceptible, if ten times as much water be added.

Aqua regia, consisting of two parts nitric and one muriatic acid, combines with tin with effervescence, and the development of much heat. In order to obtain a permanent solution of tin in this acid, it is necessary to add the metal by small portions at a time; so that the one portion may be entirely dissolved before the next piece is added. Aqua regia, in this manner, dissolves half its weight of tin. The solution is of a reddish-brown, and in many instances assumes the form of a concrete gelatinous substance. The addition of water sometimes produces the concrete form in this solution, which is then of an opal colour, on account of the oxide of tin diffused through its substance.

The uncertainty attending these experiments with the solution of tin in aqua regia, seems to depend upon the want of a sufficient degree of accuracy in ascertaining the specific gravities of the two acids which are mixed, the quantities of each, and of the tin, together with that of the water added. It is probable, that the spontaneous assumption of the concrete state, depends upon water imbibed from the atmosphere. The solution of tin in aqua regia is used by dyers to heighten the colours of cochineal, gum-lac, and some other red tinctures, from crimson to a bright scarlet, in the dyeing of woollens.

The acetic acid scarcely acts upon tin. The operation of other acids upon this metal has been little inquired into. Phosphate, fluate, and borate of tin have been formed by precipitating the muriate with the respective neutral salts.

If the crystals of the saline combination of copper with the nitric acid be grossly powdered, moistened, and rolled up in tin-foil, the salt deliquesces, nitrous fumes are emitted, the mass becomes hot, and suddenly takes fire. In this experiment, the rapid transition of the nitric acid to the tin, is supposed to produce or develope heat enough to set fire to the nitric salts; but by what particular changes of capacity, has not been shown.

If small pieces of phosphorus be thrown on tin in fusion, it will take up from 15 to 20 per cent, and form a silvery white phosphuret of a foliated texture, and soft enough to be cut with a knife, though but little malleable. This phosphuret may be formed likewise by fusing tin filings with concrete phosphoric acid.

Tin unites with bismuth by fusion, and becomes harder and more brittle in proportion to the quantity of that metal added. With nickel it forms a white brilliant mass. It cannot easily be united in the direct way with arsenic, on account of the volatility of this metal; but by heating it with the combination of the arsenical acid and potash, the salt is partly decomposed; and the tin combining with the acid, becomes converted into a brilliant brittle compound, of a plaited texture. It has been said, that all tin contains arsenic; and that the crackling noise which is heard upon bending pieces of tin, is produced by this impurity; but, from the experiment of Bayen, this appears not to be the fact. Cobalt unites with tin by fusion; and forms a grained mixture of a colour slightly inclining to violet. Zinc unites very well with tin, increasing its hardness, and diminishing its ductility, in proportion as the quantity of zinc is greater.

This is one of the principal additions used in making pewter, which consists for the most part of tin. The best pewter does not contain above one-twentieth part of admixture, which consists of zinc, copper, bismuth, or such other metallic substances, as experience has shown to be most conducive to the improvement of its hardness and colour. The inferior sorts of pewter, more especially those used abroad, contain much lead, have a bluish colour, and are soft. The tin usually met with in commerce in this country, has no admixture to impair its purity, except such as may accidentally elude the workmen at the mines. But the tin met with in foreign countries, is so much debased by the dealers in that article, especially the Dutch, that pewter and tin are considered abroad as the same substance.

Antimony forms a very brittle hard mixture with tin; the specific gravity of which is less than would have been deduced by computation from the specific gravities and quantities of each, separately taken. Tungsten, fused with twice its weight of tin, affords a brown spongy mass, which is somewhat ductile.

The uses of tin are very numerous, and so well known, that they scarcely need be pointed out. Several of them have been already mentioned. The tinning of iron and copper, the silvering of looking-glasses, and the fabrication of a great variety of vessels and utensils for domestic and other uses, are among the advantages derived from this vessel.

Tincal. Crude borax, as it is imported from the East Indies in yellow greasy crystals, is called tincal.

Tinglass. Bismuth.

* **Tinning.** See Iron.*

Titanites. This name has been given to certain ores of titanium, containing that metal in the state of oxide. See the following article.

Titanium. About twenty years ago, the Rev. Mr. Gregor discovered in a kind of ferruginous sand, found in the vale of Menachan, in Cornwall, what he supposed to be the oxide of a new metal, but was unable to reduce.

Klaproth, afterward analyzing what was called the real schorl of Hungary, found it to be the pure oxide of a new metal, which he named titanium, and the same with the menachanite of Mr. Gregor. Since that oxide of titanium has been discovered in several fossils.

We do not know that titanium has been completely reduced, except by Lampadius, who effected it by means of charcoal only. The oxide he employed was obtained from the decomposition of gallate of titanium by fixed alkali. The metal was of a dark copper colour, with much metallic brilliancy, brittle, and in small scales considerably elastic. It tarnishes in the air, and is easily oxidized by heat. It then acquires a bluish aspect. It detonates with nitre, and is highly infusible. All the dense acids act upon it with considerable energy. According to Vauquelin, it is volatilized by intense heat.

The native red oxide is insoluble in the sulphuric, nitric, muriatic, and nitro-muriatic acids: but if it be fused with six parts of carbonate of potash, the oxide is dissolved with effervescence. The sulphuric solution when evaporated becomes gelatinous; the nitric affords rhomboidal crystals by spontaneous evaporation, but is rendered turbid by ebullition; the muriatic becomes gelatinous, or flocculent, by heat, and transparent crystals form in it when cooled; but if it be boiled, oxygenized muriatic acid gas is evolved, and a white oxide thrown down. Phosphoric and arsenic acids take it from the others, and form with it a white precipitate. These precipitates are soluble in muriatic acid, but in no other.

The solutions of titanium give white precipitates with the alkalis, or their carbonates; tincture of galls gives a brownish-red, and prussiate of potash, a brownish-yellow. If the prussiate produce a green precipitate, this, according to Lowitz, is owing to the presence of iron. Zinc, immersed in the solutions, changes their colour from yellow to violet, and ultimately to an indigo; tin produces in them a pale red tint, which deepens to a bright purple-red. Hydrosulphuret of potash throws down a brownish-red precipitate, but they are not decomposed by sulphuretted hydrogen.

By exposing phosphate of titanium, mixed with charcoal and borax, to a violent heat, in a double crucible luted, M. Chenevix obtained a pale white phosphuret, with some lustre, brittle, of a granular texture, and not very fusible.

The oxides of iron and titanium, exposed to heat with a little oil and charcoal, produce an alloy of a gray colour, intermixed with brilliant metallic particles of a golden yellow.

Oxide of titanium was used to give a brown or yellow colour in painting on porcelain, before its nature was known; but it was found difficult to obtain from it a uniform tint, probably from its not being in a state of purity.

* TOBACCO. The expressed juice of the leaves, according to Vauquelin, contain the following substances:—

A considerable quantity of vegetable albumen or gluten; supermalate of lime; acetic acid.

A notable quantity of nitrate and muriate of potash. A red matter soluble in alcohol and water, which swells considerably when heated.

Muriate of ammonia.

Nicotin.

Green fecula composed chiefly of gluten, green resin, and woody fibre.*

TOLU (BALSAM OF). This substance is obtained from the toluifera balsamum, a tree which grows in South America. The balsam flows from incisions made in the bark. It comes to Europe in small gourd shells. It is of a reddish-brown colour and considerable consistence; and when exposed to the air, it becomes solid and brittle. Its smell is fragrant, and continues so, even after the balsam has become thick by age. When distilled with water, it yields very little volatile oil, but impregnates the water strongly with its taste and smell. A quantity of benzoic acid sublimes if the distillation be continued.

Mr. Hatchett found it soluble in the alkalis, like the rest of the balsams. When he dissolved it in the smallest possible quantity of lixivium of potash, it completely lost its own odour, and assumed a fragrant smell; somewhat resembling that of the clove pink. "This smell," Mr. Hatchett observes, "is not fugitive, for it is still retained by a solution, which was prepared in June, and has remained in an open glass during four months."

When digested in sulphuric acid, a considerable quantity of pure benzoic acid sublimes. When the solution of it in this acid is evaporated to dryness, and the residuum treated with alcohol, a portion of artificial tannin is obtained; the residual charcoal amounts to 0.54 of the original balsam.

Mr. Hatchett found, that it dissolved in nitric acid, with nearly the same phenomena as the resins; but it assumed the smell of bitter almonds, which led him to suspect the formation of prussic acid. During the solution in nitric acid, a portion of benzoic acid sublimes. By repeated digestions, it is converted into artificial tannin.

It is totally soluble in alcohol, from which water separates the whole of it, except the benzoic acid.

TOMBAC. A white alloy of copper with arsenic, commonly brittle; though if the quantity of arsenic be small, it is both ductile and malleable in a certain degree. It is sometimes called white copper.

* TOPAZ. According to Professor Jameson, this mineral species contains three sub-species, common topaz, schorlite, and physalite.

Common topaz. Colour wine-yellow. In granular concretions, disseminated and crystallized. Its primitive form is an oblique prism of 124° 22′. The following are secondary forms. An oblique four-sided prism, acuminated by four planes; the same, with the acute lateral edges bevelled; the same, with a double acumination, and several other modifications, for which consult Jameson's Min. vol. i. p. 75. The lateral planes are longitudinally streaked. Splendent and vitreous. Cleavage perfect and perpendicular to the axis of the prism. Fracture, small conchoidal. Transparent. Refracts double. Harder than quartz, or emerald; but softer than corundum. Easily frangible. Sp. gr. 3.4 to 3.6.

Saxon topaz in a gentle heat becomes white, but a strong heat deprives it of lustre and transparency. The Brazilian, on the contrary, by exposure to a high temperature, burns rose-red, and in a still higher, violet-blue. Before the blow-pipe it is infusible. The topaz of Brazil, Siberia, Mucla in Asia-Minor, and Saxony, when heated, exhibit at one extremity, positive, and at the other, negative electricity. It also becomes electrical by friction; and retains its electricity very long. Its constituents are,

	Braz. Top.	*Sax. T.*	*Sax. T.*
Alumina,	58.38	57.45	59
Silica,	34.01	34.24	35
Fluoric acid,	7.79	7.75	5
	100.18	99.44	99
	Berzelius.	*Klapr.*	*Klapr.*

Topaz forms an essential constituent of a particular mountain-rock, which is an aggregate of topaz, quartz, and schorl, and is named topaz-rock. Topaz occurs in drusy cavities in granite. It has been also discovered in nests, in transition clay-slate; and it is found in rolled pieces in alluvial soil. It occurs in large crystals, and rolled masses, in an alluvial soil, in the granite and gneiss districts of Mar and Cairngorm, in the upper parts of Aberdeenshire; and in veins, along with tin-stone, in clay-slate at St. Anne's, Cornwall. On the continent, it appears most abundantly in topaz-rock at Schneckenstein.—*Jameson.**

* TOPAZOLITE. A variety of precious garnet, found at Mussa in Piedmont.*

* TORTOISE-SHELL. It approaches to nail or coagulated albumen in its composition. 500 parts, after incineration, leave three of earthy matter, consisting of phosphate of lime, and soda, with a little iron.*

* TOUCHSTONE. Lydian stone, a variety of *flinty-slate.**

* TOURMALINE. Rhomboidal tourmaline is divided into two sub-species, *schorl* and *tourmaline*.

Tourmaline. Colours green and brown. In prismatic concretions, rolled pieces, but generally crystallized. Primitive form, a rhomboid of 133° 26′. It occurs in an equiangular three-sided prism, flatly acuminated on the extremities with three planes. The lateral edges are frequently bevelled, and thus a nine-sided prism is formed: when the edges of the bevelment are truncated, a twelve-sided prism is formed; and when the bevelling planes increase so much, that the original faces of the prism disappear, an equiangular six-sided prism is formed. Sometimes the prism is nearly awanting, when a double three-sided pyramid is formed. The lateral planes are generally cylindrical convex, and deeply longitudinally streaked. Crystals imbedded. Splendent, vitreous. Cleavage threefold. Fracture conchoidal. Opaque to transparent. Refracts double. When viewed perpendicular to the axis of the crystal, it is more or less transparent; but in the direction of the axis, even when the length of the prism is less than the thickness, it is opaque. As hard as quartz. Easily frangible. Sp. gr. 3.0 to 3.2. By friction it yields vitreous electricity; by heating, vitreous at one end, and resinous at the other. The brown and hyacinth-red varieties, have these properties in the greatest degree. The ancients called it *lyncurium.* Before the blow-pipe, it melts into a grayish-white vesicular enamel. Its constituents are, silica 42, alumina 40, soda 10, oxide of manganese with a little iron 7, loss 1.—*Vauquelin.* It occurs in gneiss, mica-slate, talc-slate, &c. The red occurs in Siberia, Ava, and Ceylon.—*Jameson.**

TRAGACANTH (GUM). This substance, which is vulgarly called gum-dragon, exudes from a prickly bush, the *astragalus tragacantha*, Lin. which grows wild in the warmer climates, and endures the cold of our own, but does not here yield any gum. This commodity is brought chiefly from Turkey, in irregular lumps, or long vermicular pieces bent into a variety of shapes; the best sort is white, semi-transparent, dry, yet somewhat soft to the touch.

Gum-tragacanth differs from all the other known gums, in giving a thick consistence to a much larger quantity of water; and in being much more difficultly soluble, or rather dissolving only imperfectly. Put into water, it slowly imbibes a great quantity of the liquid, swells into a large volume, and forms a soft but not fluid mucilage; if more water be added, a fluid solution may be obtained by agitation: but the liquor looks turbid and wheyish, and on standing, the mucilage subsides, the limpid water on the surface retaining little of the gum. Nor does the admixture of the preceding more soluble gums promote its union with the water, or render its dissolution more durable: when gum-tragacanth, and gum-arabic are dissolved together in water, the tragacanth seems to separate from the mixture more speedily than when dissolved by itself.

Tragacanth is usually preferred to the other gums for making up troches, and other like purposes, and is supposed likewise to be the most effectual as a medicine; but on account of its imperfect solubility, is unfit for liquid forms. It is commonly given in powder with the addition of other materials of similar intention; thus to one part of gum-tragacanth, are added one of gum-arabic, one of starch, and six of sugar. See CERASIN.

* TRAP FORMATIONS in geology.

Primitive trap. The name trap is derived from the Swedish word *trappa*, a stair. Werner understands by trap, rocks principally characterized by the presence of hornblende, and black iron clay. Hence all rocks occurring in the primitive class, having hornblende as a characteristic, or predominating ingredient, belong to the *primitive trap formation.* The following table from Professor Jameson exhibits the rocks of this formation.

1. Common hornblende rock.
    - *a.* Granular hornblende rock.
    - *b.* Hornblende slate.
2. Hornblende mixed with feldspar.
    - *a.* Greenstone.
        - α. Common greenstone.
        - β. Porphyritic greenstone.
        - γ. Greenstone porphyry.
        - δ. Green porphyry.
    - *b.* Greenstone slate.
3. Hornblende mixed with mica.

Transition trap. It contains greenstone and amygdaloid.

The *newest floetz-trap* contains several rocks which are peculiar to it, and others that occur in other floetz formations. The peculiar or characteristic rocks are, *basalt*, *wacke*, *gray-stone*, *porphyry-slate*, and trap-tuff. These, and also greenstone, are often called whinstone by mineralogists.*

* **Trap-tuff.** It is composed of masses of basalt, amygdaloid, hornblende rock, sand-stone, and even pieces of wood (as in thei sland of Canna) cemented together by a rather loose spongy clayey basis, which has been formed from decomposed basalt or wacke rock. The masses vary much in size, from that of a pea, to several hundred weight. It occurs in beds, which are from a few inches to several fathoms thick. A considerable portion of Arthur's-seat, near Edinburgh, is composed of this rock: there it rests on inclined strata, which belong to the oldest coal formation. It occurs also in Mull, and many other places in Scotland.*

* **Tremolite.** This sub-species of straight-edged augite is divided into three kinds; the asbestous, common, and glassy.

1. *Asbestous tremolite.* Colour grayish-white. Massive, and in fibrous concretions. Shining, pearly. Fragments splintery. Translucent on the edges. Rather easily frangible. Soft. Rather sectile. When struck gently, or rubbed in the dark, it emits a pale reddish light; when pounded and thrown on coals, a greenish light. Before the blow-pipe, it melts into a white opaque mass. It occurs most frequently in granular foliated limestone, or in dolomite. It is found in the former in Glentilt and Glenelg; in the latter, in Aberdeenshire and Icolmkill; and in basalt in the Castle-rock of Edinburgh.

2. *Common tremolite.* Colour white. Massive, in distinct prismatic concretions, and crystallized in a very oblique four-sided prism, truncated or bevelled on the lateral edges; in an extremely oblique four-sided prism, perfect or variously modified by bevelment or truncation. The lateral planes are longitudinally streaked. Vitreous or pearly. Cleavage double oblique angular, of 124° 50′ and 55° 50′. Fracture uneven or conchoidal. Translucent. As hard as hornblende. Rather brittle. Sp. grav. 2.9 to 3.2. It melts with much difficulty and ebullition into an opaque glass. Its constituents are, silica 50, magnesia 25, lime 18, carbonic acid and water 5.—*Laugier.* It occurs with the preceding.

3. *Glassy tremolite.* Colour grayish, greenish, yellowish, and reddish-white. Massive, in distinct concretions, and frequently crystallized in long acicular crystals. Shining, between vitreous and pearly. Translucent. As hard as hornblende. Very brittle. Sp. gr. 2.863. It is phosphorescent in a low degree. Infusible. Its constituents are, silica 35.5, lime 26.5, magnesia 16.5, water and carbonic acid 23.—*Laugier.* It occurs with the preceding.—*Jameson.**

* **Triphane.** See **Spodumene.***

* **Tripoli.** Colour yellowish-gray. Massive. Fracture fine or coarse earthy. Opaque. Soft. Rather easily frangible. Meagre. Does not adhere to the tongue. Sp. gr. 2.2. Infusible. Its constituents are, silica, 81, alumina 1.5, oxide of iron 8, sulphuric acid 3.45, water 4.55.—*Bucholz.* Of the *rottenstone*, silica 4, alumina 86, carbon 10.—*Phillips.* It occurs in beds in coal-fields, with secondary limestone, and under basalt. It is found at Bakewell, in Derbyshire, where it is called *rottenstone.* It is used for polishing stones, metals, and glasses. The *tripoli* of Corfu is reckoned the most valuable.*

* **Trona.** The name given in Africa to the native carbonate of soda, found at Sukena, near Fezzan.*

Tube of Safety. A tube open at both ends, inserted into a receiver, the upper end communicating with the external air, and the lower being immersed in water. Its intention is to prevent injury from too sudden condensation or rarefaction taking place during an operation. For, if a vacuum be produced within the vessels, the external air will enter through the tube: and if air be generated, the water will yield to the pressure, being forced up the tube. Thus, too, the height of the water in the tube indicates the degree of pressure from the confined gas or gases. See Pl. VII. fig. 3. *h.* It is now more frequently used in a curved form, *ib.* fig. 1.; and is commonly called a Welter's tube.

* **Tufaceous Limestone,** or **Calc Tuff.** See **Limestone.***

Tumite. See **Thummerstone.**

* **Tungsten.** See **Ores of Tungsten.***

Tungstenum. This name, signifying heavy stone, was given by the Swedes to a mineral, which Scheele found to contain a peculiar metal, as he supposed, in the state of an acid, united with lime. The same metallic substance was afterward found by the Don d'Elhuyarts united with iron and manganese in wolfram.

From the first of these the oxide may be obtained by digesting its powder in thrice its weight of nitric acid; washing the yellow powder that remains, and digesting it in ammonia, by which a portion of it is dissolved. These alternate digestions are to be repeated, and the tungstic oxide precipitated from the ammoniacal solutions by nitric acid. The precipitate is to be washed with water, and exposed to a moderate heat, to expel any ammonia that may adhere to it. Or the mixture may be evaporated to a dry mass, which is to be calcined under a muffle, to dissipate the nitrate of ammonia. From wolfram it may be obtained by the same process, after the iron and manganese have been dissolved by muriatic acid.

The Spanish chemists reduced the oxide of tungsten to the metallic state, by exposing it moistened with oil, in a crucible lined with charcoal, to an intense heat. After two hours, a piece of metal weighing 40 grains, but slightly agglutinated, was found at the bottom of the crucible. Some have attempted its reduction in vain; but Guyton, Ruprecht, and Messrs. Aikin and Allen, have been more successful. The latter gentlemen produced it from the ammoniuret. From 240 grains of this substance, in acicular crystals, exposed for two hours to a powerful wind furnace, in a crucible lined with charcoal, they obtained a slightly cohering mass of roundish grains, about the size of a pin's head, with a very brilliant metallic lustre, and weighing in the whole 161 grains.

Tungsten is said to be of a grayish-white or iron colour, with considerable brilliancy, very hard, and brittle. Its specific gravity Don d'Elhuyarts found to be 17.6; Messrs. Aikin and Allen, above 17.22.

* There are two oxides of tungstenum, the brown, and the yellow or tungstic acid.

The brown oxide is formed by transmitting hydrogen gas over tungstic acid, in an ignited glass tube. It has a flea-brown colour, and when heated in the air, it takes fire and burns like tinder, passing into *tungstic acid;* which see.

The brown oxide consists of

Tungstenum,	100
Oxygen,	16.6—*Berzel.*

Hence, if we regard it as composed of 2 primes oxygen + 1 metal, its composition will be

Tungstenum,	12.05	100.
Oxygen,	2.00	16.6

Hence the acid prime ought probably to be, 12.05 + 3. = 15.05 or 15; and that of the metal 12.

But from Berzelius's experiments, tungstate of lime seems to consist of

Tungstic acid,	100.	14.72
Lime,	24.12	3.55

The difference indeed is not great.

Sir H. Davy found that tungstenum burns with a deep red light, when heated in chlorine, and forms an orange-coloured volatile substance, which affords the yellow oxide of tungstenum, and muriatic acid, when decomposed by water.*

Scheele supposed the white powder, obtained by digesting the ore in an acid, adding ammonia to the residuum, and neutralizing it by nitric acid, to be pure acid of tungsten. In fact it has a sour taste, reddens litmus, forms neutral crystallizable salts with alkalis, and is soluble in 20 parts of boiling water. It appears however to be a triple salt, composed of nitric acid, ammonia, and oxide of tungsten; from which the oxide may be obtained in a yellow powder by boiling with a pure concentrated acid. In this state it contains about 20 per cent of oxygen; part of which may be expelled by a red heat, when it assumes a green colour.

Tungsten is insoluble in the acids; and its oxide is nearly the same. It appears to be capable of uniting with most other metals, but not with sulphur. Guyton found, that the oxide gives great permanence to vegetable colours.—*Scheele's Essays.*—*Brongniart's Min.*—*Nich. Journ.*—*Phil. Mag.*—*Murray's Chemistry.*

TUNGSTEN OF BASTNAS, or FALSE TUNGSTEN. See CERIUM.

* TURPETH MINERAL. Yellow subdeutosulphate of mercury.*

TURNSOLE. Heliotropium. See ARCHIL.

TURKEY STONE. Cos Turcica. See WHETSLATE.

TURMERIC (*terra merita*), *curcuma longa*, is a root brought to us from the East Indies. Berthollet had an opportunity of examining some turmeric that came from Tobago, which was superior to that which is met with in commerce, both in the size of the roots and the abundance of the colouring particles. This substance is very rich in colour, and there is no other which gives a yellow colour of such brightness; but it possesses no durability, nor can mordants give it a sufficient degree. Common salt and sal ammoniac, are those which fix the colour best, but they render it deeper and make it incline to brown: some recommend a small quantity of muriatic acid. The root must be reduced to powder to be fit for use. It is sometimes employed to give the yellows made with weld a gold cast, and to give an orange tinge to scarlet; but the shade the turmeric imparts, soon disappears in the air.

Mr. Guchliche gives two processes for fixing the colour of turmeric on silk. The first consists in aluming in the cold for twelve hours, a pound of silk in a solution of two ounces of alum, and dyeing it hot, but without boiling, in a bath composed of two ounces of turmeric and a quart (measure) of aceto-citric acid, mixed with three quarts of water. The second process consists in extracting the colouring particles from the turmeric by aceto-citric acid, in the way described for Brazil wood, and in dyeing the silk, alumed as already mentioned, in this liquor, either cold or only modederately warm. The colour is rendered more durable by this than by the former process. The first parcel immersed acquires a gold yellow; the colour of the second and third parcels is lighter, but of the same kind; that of the fourth is a straw colour. Mr. Guchliche employs the same process to extract fine and durable colours from fustic, broom, and French berries; he prepares the wool by a slight aluming, to which he adds a little muriatic acid. He seems to content himself in these cases with vinegar or some other vegetable acid, instead of his aceto-citric acid, for the extraction of the colour; he directs that a very small quantity of solution of tin should be put into the dye-bath.

TURPENTINE is a resinous juice extracted from several trees. Sixteen ounces of Venice turpentine, being distilled with water, yielded four ounces and three drachms of essential oil; and the same quantity, distilled without water, yielded with the heat of a water-bath, two ounces only. When turpentine is distilled or boiled with water till it becomes solid, it appears yellowish; when the process is farther continued, it acquires a reddish-brown colour. On distilling sixteen ounces in a retort with an open fire, increased by degrees, Neumann obtained, first, four ounces of a limpid colourless oil; then two ounces and a drachm of a dark brownish-red empyreumatic oil, of the consistence of a balsam, and commonly distinguished by that name.

The essential oil, commonly called spirit of turpentine, cannot without singular difficulty be dissolved in alcohol, though terpentine itself is easily soluble in that spirit. One part of the oil may be dissolved in seven parts of alcohol; but on standing a while, the greatest part of the oil separates and falls to the bottom.

* TURQUOIS, MINERAL, or CALAITE. Colours smalt-blue and apple-green. Massive, disseminated, and imitative. Dull. Fracture conchoidal or uneven. Opaque. Harder than feldspar, but softer than quartz. Streak, white. Sp. gr. 2.86 to 3.0. Its constituents are, alumina 73, oxide of copper 4.5, water 18, oxide of iron 4.—*John.* It occurs in veins in clay-ironstone, and in small pieces in alluvial clay. It has been found only in the neighbourhood of Nichabour, in the Khorassan, in Persia. It is very highly prized as an ornamental stone in Persia, and the neighbouring countries. Malchite yields a green streak, but that of calaite is white. *Bone turquois* is phosphate of lime, coloured with oxide of copper.*

TUTENAG. This name is given in India to the metal zinc. It is sometimes applied to denote a white metallic compound, brought from China, called also *Chinese copper*, the art of making which is not known in Europe. It is very tough, strong, malleable, may be easily cast, hammered, and polished; and the better kinds of it, when well manufactured, are very white, and not more disposed to tarnish than silver is. Three ingredients of this compound may be discovered by analysis; namely, copper, zinc, and iron.

Some of the chinese white copper is said to be merely copper and arsenic.

TYPE METAL. The basis of type metal for printers is lead, and the principal article used in communicating hardness is antimony, to which copper and brass in various proportions are added. The properties of a good type metal are, that it should run freely into the mould, and possess hardness without being excessively brittle. The smaller letters are made of a harder composition than those of a larger size. It does not appear that our type-founders are in possession of a good composition for this purpose. The principal defect of their composition appears to be, that the metals do not uniformly unite. In a piece of casting performed at one of our principal founderies, the thickness of which was two inches, I found one side hard and brittle when scraped, and the other side, consisting of nearly half the piece, was soft like lead. The transition from soft to hard was sudden, not gradual. If a parcel of letter of the same size and casting be examined, some of them are brittle and hard, and resist the knife, but others may be bent and cut into shavings. It may easily be imagined, that the duration and neatness of these types must considerably vary. I have been informed, but do not know the fact from trial, that the types cast in Scotland are harder and more uniform in their qualities.

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ULMIN. Dr. Thomson has given this temporary name to a very singular substance lately examined by Klaproth. It differs essentially from every other known body, and must therefore constitute a new and peculiar vegetable principle. It exuded spontaneously from the trunks of a species of elm, which Klaproth conjectures to be the *ulmus nigra*, and was sent to him from Palermo in 1802.

1. In its external characters it resembles gum. It was solid, hard, of a black colour, and had considerable lustre. Its powder was brown. It dissolved readily in the mouth, and was insipid.

2. It dissolved speedily in a small quantity of water. The solution was transparent, of a blackish-brown colour, and, even when very much concentrated by evaporation, was not in the least mucilaginous or

ropy; nor did it answer as a paste. In this respect ulmin differs essentially from gum.

3. It was completely insoluble both in alcohol and ether. When alcohol was poured into the aqueous solution, the greater part of the ulmin precipitated in light brown flakes. The remainder was obtained by evaporation, and was not sensibly soluble in alcohol. The alcohol by this treatment acquired a sharpish taste.

4. When a few drops of nitric acid were added to the aqueous solution, it became gelatinous, lost its blackish-brown colour, and a light brown substance precipitated. The whole solution was slowly evaporated to dryness, and the reddish-brown powder, which remained, was treated with alcohol. The alcohol assumed a golden-yellow colour; and when evaporated, left a light-brown, bitter, and sharp resinous substance.

5. Oxymuriatic acid produced precisely the same effects as nitric. Thus it appears that ulmin, by the addition of a little oxygen, is converted into a resinous substance. In this new state it is insoluble in water. This property is very singular. Hitherto the volatile oils were the only substances known to assume the form of resins. That a substance soluble in water should assume the resinous form with such facility, is very remarkable.

6. Ulmin, when burnt, emitted little smoke or flame, and left a spongy but firm charcoal, which, when burnt in the open air, left only a little carbonate of potash behind.

Such are the properties of this curious substance, as far as they have been examined by Klaproth.

Ultramarine. See Azure-stone.

* **Umber.** See Ores of Iron.*

Uranglimmer. An ore of uranium, formerly called *green mica*, and by Werner *chalcolite*. See the following article.

Uranite, *or* **Uranium.** A new metallic substance, discovered by the celebrated Klaproth in the mineral called *Pechblende*. In this it is in the state of sulphuret. But it likewise occurs as an oxide in the green mica, or uranglimmer, and in the uranochre.

By treating the ores of the metal with the nitric or nitro-muriatic acid, the oxide will be dissolved; and may be precipitated by the addition of a caustic alkali. It is insoluble in water, and of a yellow colour; but a strong heat renders it of a brownish-gray.

To obtain it pure, the ore should be treated with nitric acid, the solution evaporated to dryness, and the residuum heated, so as to render any iron it may contain insoluble. This being treated with distilled water, ammonia is to be poured into the solution, and digested with it for some time, which will precipitate the uranium and retain the copper. The precipitate, well washed with ammonia, is to be dissolved in nitric acid, and crystallized. The green crystals, dried on blotting paper, are to be dissolved in water, and recrystallized, so as to get rid of the lime. Lastly, the nitrate, being exposed to a red heat, will be converted into the yellow oxide of uranium.

It is very difficult of reduction. Fifty grains, after being ignited, were formed into a ball with wax, and exposed in a well closed charcoal crucible, to the most vehement heat of a porcelain furnace, the intensity of which gave 170° on Wedgwood's pyrometer. Thus a metallic button was obtained, weighing 28 grains, of a dark gray colour, hard, firmly cohering, fine grained, of very minute pores, and externally glittering. On filing it, or rubbing it with another hard body, the metallic lustre has an iron-gray colour; but in less perfect assays it verges to a brown. Its specific gravity was 8.1. Bucholz, however, obtained it as high as 9.0

* There is probably but two oxides of uranium; the protoxide, which is grayish-black; and the peroxide, which is yellow.

When uranium is heated to redness in an open vessel, it glows like a live coal, and passes into the protoxide, which, from the experiments of Shoübert, consists of

Uranium,	100	15.7
Oxygen,	6.373	1.0

The precipitate thrown down by potash from the nitrate solution is called the *yellow oxide*. It consists of

Uranium,	100	31.4 = 2 primes
Oxygen,	9.359	3.0 = 3*

The oxide is soluble in dilute sulphuric acid gently heated, and affords lemon-coloured prismatic crystals. Its solution in muriatic acid, in which it is but imperfectly soluble, affords yellowish-green rhomboidal tablets. Phosphoric acid dissolves it, but after some time the phosphate falls down in a flocculent form, and of a pale yellow colour.

It combines with vitrifiable substances, and gives them a brown or green colour. On porcelain, with the usual flux, it produces an orange.

Uranochre. An ore of uranium, containing this metal in the oxidized state. See the preceding article.

* **Urates.** Compounds of uric or lithic acid, with the salifiable bases. See Acid (Lithic).*

* **Urea.** The best process for preparing urea is to evaporate urine to the consistence of sirup, taking care to regulate the heat towards the end of the evaporation; to add very gradually to the sirup its volume of nitric acid (24° Baumé) of 1.20; to stir the mixture, and immerse it in a

bath of iced water, to harden the crystals of the acidulous nitrate of urea which precipitate; to wash these crystals with ice-cold water, to drain them, and press them between folds of blotting paper. When we have thus separated the adhering heterogeneous matters, we redissolve the crystals in water, and add to them a sufficient quantity of carbonate of potash, to neutralize the nitric acid. We must then evaporate the new liquor, at a gentle heat, almost to dryness; and treat the residuum with very pure alcohol, which dissolves only the urea. On concentrating the alcoholic solution, the urea crystallizes.

The preceding is M. Thenard's process, which Dr. Prout has improved. He separates the nitrate of potash by crystallization, makes the liquid urea into a paste with animal charcoal, digests this with cold water, filters, concentrates, then dissolves the new colourless urea in alcohol, and lastly crystallizes. The process prescribed by Dr. Thomson, in the 5th edition of his System, does not answer.

Urea crystallizes in four-sided prisms, which are transparent and colourless, with a slight pearly lustre. It has a peculiar, but not urinous odour; it does not affect litmus or turmeric papers; it undergoes no change from the atmosphere, except a slight deliquescence in very damp weather. In a strong heat it melts, and is partly decomposed and partly sublimed without change. The sp. gr. of the crystals is about 1.35. It is very soluble in water. Alcohol, at the temperature of the atmosphere, dissolves about 20 per cent; and when boiling, considerably more than its own weight, from which the urea separates, on cooling, in its crystalline form. The fixed alkalis and alkaline earths decompose it. It unites with most of the metallic oxides; and forms crystalline compounds with the nitric and oxalic acids.*

If cautiously introduced into a retort with a wide short neck, it fuses with a gentle heat: a white fume rises, which is benzoic acid, and condenses on the sides of the receiver: crystallized carbonate of ammonia succeeds, and continues to the end: neither water nor oil rises, but the sublimate is turned brown: the air expelled from the apparatus is impregnated with a smell of garlic and stinking fish: when the heat is very intense, the smell is insupportable. The matter in the retort is then dry, blackish, and covered with a raised white crust, which rises at length in a heavy vapour, and attaches itself to the lower part of the retort. This is muriate of ammonia.

If water be poured on the residuum, it emits a smell of prussic acid. Burned on an open fire it exhales the same smell, gives out ammonia, and leaves one-hundredth of its weight of acrid white ashes, which turn sirup of violets green, and contain a small quantity of carbonate of soda.

The aqueous solution, distilled by a gentle fire, and carried to ebullition, affords very clear water loaded with ammonia. By adding more water, as the liquor became inspissated, Fourcroy and Vauquelin obtained nearly two-thirds of the weight of the urea in carbonate of ammonia, and the residuum was not then exhausted of it. The latter portions, however, were more and more coloured.

This decomposition of an animal substance at the low heat of boiling water is very remarkable, particularly with respect to the carbonic acid. Indeed it appears that a very slight change of equilibrium is sufficient to cause its constituent principles to pass into the state of ammonia, and carbonic, prussic, and acetous acids.

* Urea has been recently analyzed by Dr. Prout, and M. Berard. The following are its constituents:—

	Per cent.	*Per cent.*	*Per atom.*
Hydrogen,	10.80	6.66	2 = 2.5
Carbon,	19.40	19.99	1 = 7.5
Oxygen,	26.40	26.66	1 = 10.0
Azote,	43.40	46.66	1 = 17.5
	100.00	100.00	37.5

See Sugar for some remarks on the relation between it and urea. Uric, or lithic acid, is a substance quite distinct from urea in its composition. This fact, according to Dr. Prout, explains, why an excess of urea generally accompanies the phosphoric diathesis, and not the lithic. He has several times seen urea as abundant in the urine of a person where the phosphoric diathesis prevailed, as to crystallize spontaneously on the addition of nitric acid, without being concentrated by evaporation.

As urea and uric acid, says Dr. Berard, are the most azotized of all animal substances, the secretion of urine appears to have for its object, the separation of the excess of azote from the blood, as respiration separates from it the excess of carbon.*

Urea has a singular effect on the crystallization of some salts. If muriate of soda be dissolved in a solution of urea, it will crystallize by evaporation, not in cubes, but in octaëdra; muriate of ammonia, on the contrary, treated in the same way, instead of crystallizing in octaëdra, will assume the cubic form. The same effect is produced, if fresh urine be employed.

Uric Acid. See Acid (Lithic).

Urine. This excrementitious fluid, in its natural state, is transparent, of a yellow colour, a peculiar smell and saline taste. Its production as to quantity, and in some measure quality, depends on the seasons and the peculiar constitution of the individual, and is likewise modified by disease. It is observed, that perspiration carries off more or less of the fluid, which would else have passed off by urine; so that the profusion of the former is attended with a diminution of the latter.

From the alkaline smell of urine kept for a certain time, and other circumstances, it was formerly supposed to be an alkaline fluid; but by its reddening paper stained blue with litmus or the juice of radishes, it appears to contain an excess of acid.

The numerous researches made concerning urine have given the following as its component parts: 1, water; 2, urea; 3, phosphoric acid; 4, 5, 6, 7, phosphates of lime, magnesia, soda, and ammonia; 8, 9, 10, 11, lithic, rosacic, benzoic, and carbonic acids; 12, carbonate of lime; 13, 14, muriates of soda and ammonia; 15, gelatin; 16, albumen; 17, resin; 18, sulphur.

Muriate of potash may sometimes be detected in urine, by cautiously dropping into it some tartaric acid; as may sulphate of soda, or of lime, by a solution of muriate of barytes, which will throw down sulphate of barytes together with its phosphate; and these may be separated by a sufficient quantity of muriatic acid, which will take up the latter.

Urine soon undergoes spontaneous changes, which are more or less speedy and extensive, according to its state, as well as the temperature of the air. Its smell, when fresh made, and healthy, is somewhat fragrant; but this presently goes off, and is succeeded by a peculiar odour termed urinous. As it begins to be decomposed, its smell is not very unlike that of sour milk; but this soon changes to a fetid, alkaline odour. It must be observed, however, that turpentine, asparagus, and many other vegetable substances, taken as medicine, or used as food, have a very powerful effect on the smell of the urine. Its tendency to putrefaction depends almost wholly on the quantity of gelatin and albumen it contains; in many cases, where these are abundant, it comes on very quickly indeed.

* According to Berzelius, healthy human urine is composed of, water 933, urea 30.10, sulphate of potash 3.71, sulphate of soda 3.16, phosphate of soda 2.94, muriate of soda 4.45, phosphate of ammonia 1.65, muriate of ammonia 1.50, free acetic acid, with lactate of ammonia, animal matter soluble in alcohol, urea adhering to the preceding, altogether 17.14, earthy phosphates with a trace of fluate of lime 1.0, uric acid 1, mucus of the bladder 0.32, silica 0.03, in 1000.0. The phosphate of ammonia and soda, obtained from urine, by removing by alcohol the urea from its crystallized salts, was called *fusible salt of urine*, or *microcosmic salt;* and was much employed in experiments with the blow-pipe.*

The changes produced in urine by disease are considerable, and of importance to be known. It is of a red colour, small in quantity, and peculiarly acrid, in inflammatory diseases; but deposites no sediment on standing. Corrosive muriate of mercury throws down from it a copious precipitate. Toward the termination of such diseases, it becomes more abundant, and deposites a copious pink-coloured sediment, consisting of rosacic acid, with a little phosphate of lime and uric acid.

In jaundice it contains a deep yellow colouring matter, capable of staining linen. Muriatic acid renders it green, and this indicates the presence of bile. Sometimes, too, according to Fourcroy and Vauquelin, it contains a substance analogous to the yellow acid, which they formed by the action of nitric acid on muscular fibre.

In hysterical affections, it is copious, limpid, and colourless, containing much salt, but scarcely any urea or gelatin.

In dropsy the urine is generally loaded with albumen, so as to become milky, or even coagulate by heat, or on the addition of acids. In dropsy from diseased liver, however, no albumen is present; but the urine is scanty, high-coloured, and deposites the pink-coloured sediment.

In dyspepsy, or indigestion, the urine abounds in gelatin, and putrefies rapidly.

In rickets, the urine contains a great deal of a calcareous salt, which has been supposed to be phosphate of lime, but according to Bonhomme it is the oxalate.

Some instances are mentioned, in which females have voided urine of a milky appearance, and containing a certain portion of the caseous part of milk.

But among the most remarkable alterations of urine is that in the diabetes, when the urine is sometimes so loaded with sugar, as to be capable of being fermented into a vinous liquor. Upwards of 1-12th of its weight of sugar was extracted from some diabetic urine by Cruikshank, which was at the rate of twenty-nine ounces troy a-day from one patient. In this disease, however, the urine, though always in very large quantity, is sometimes not sweet, but insipid.

The urine of some animals, examined by Fourcroy, Vauquelin, and Rouelle, jun. appears to differ from that of man in wanting the phosphoric and lithic acids, and containing the benzoic. That of the horse, according to the former two, consists of benzoate of soda .024, carbonate of lime .011, carbonate of soda .009, muriate of potash .009, urea .007, water and mucilage .940. Giese, however, observes, that the proportion of benzoate of soda varies greatly, so that sometimes scarcely any can be found. Notwithstanding the assertions of these chemists, that the urine of the horse contains no phosphoric acid, Giobert affirms that phosphorus may be made from it.

That of the cow, according to Rouelle, contains carbonate, sulphate, and muriate of potash, benzoic acid, and urea: that of the camel differed from it in affording no benzoic acid: that of the rabbit, according to Vauquelin, contains the carbonates of lime, magnesia, and potash, sulphates of potash and lime, muriate of potash, urea, gelatin, and sulphur. All these appear to contain some free alkali, as they turn sirup of violets green. In the urine of domestic fowls, Fourcroy and Vauquelin found lithic acid.

Urine has been employed for making phosphorus, volatile alkali, and sal ammoniac; it adds to the produce of nitre-beds; and it is very useful in a putrid state for scouring woollens.

* **Urinary Calculi.** See **Calculi (Urinary).***

V

* **VAPOUR.** The general principles of the formation of vapour have been explained under the article **Caloric**, *changes of state*. Some observations have been added under **Evaporation** and **Gas.**

Fig. 15. plate XIV. represents one form of the apparatus, which I employed for determining the elastic force of vapours at different temperatures. L, l, are the initial levels of the mercurial columns in the two legs of the syphon barometer. *l*, is the fine wire of platina, to which the quicksilver was made a tangent, at every measurement, by pouring mercury into the open leg, till its vertical pressure equipoised the elastic force of the vapour above *l*. The column added over L, measured directly that elastic force. See the Tables in the Appendix.*

* **Varec.** The French name for kelp, or incinerated sea-weed.*

Varnish. Lac-varnishes or lacquers consist of different resins in a state of solution, of which the most common are mastich, sandarach, lac, benzoin, copal, amber, and asphaltum. The menstrua are either expressed or essential oils, as also alcohol. For a lac-varnish of the first kind, the common painter's varnish is to be united by gently boiling it with some more mastich or colophony, and then diluted again with a little more oil of turpentine. The latter addition promotes both the glossy appearance and drying of the varnish.

Of this sort is the amber-varnish. To make this varnish, half a pound of amber is kept over a gentle fire in a covered iron pot, in the lid of which there is a small hole, till it is observed to become soft, and to be melted together into one mass. As soon as this is perceived, the vessel is taken from off the fire, and suffered to cool a little; when a pound of good painter's varnish is added to it, and the whole suffered to boil up again over the fire, keeping it continually stirring. After this, it is again removed from the fire; and when it is become somewhat cool, a pound of oil of turpentine is to be gradually mixed with it. Should the varnish, when it is cool, happen to be yet too thick, it may be attenuated with more oil of turpentine. This varnish has always a dark-brown colour, because the amber is previously half burned in this operation; but if it be required of a bright colour, amber powder must be dissolved in transparent painter's varnish, in Papin's machine, by a gentle fire.

As an instance of the second sort of lac-varnishes with ethereal oils alone, may be adduced the varnish made with oil of turpentine. For making this, mastich alone is dissolved in oil of turpentine by a very gentle digesting heat, in close glass vessels. This is the varnish used for the modern transparencies employed as window-blinds, fire-screens, and for other purposes. These are commonly prints, coloured on both sides, and afterwards coated with this varnish on those parts that are intended to be transparent. Sometimes fine thin calico, or Irish linen, is used for this purpose; but it requires to be primed with a a solution of isinglass, before the colour is laid on.

Copal may be dissolved in genuine Chio turpentine, according to Mr. Sheldrake, by adding it in powder to the turpentine previously melted, and stirring till the whole is fused. Oil of turpentine may then be added, to dilute it sufficiently. Or the copal in powder may be put into a long-necked matrass with twelve parts of oil of turpentine, and digested several days on a sand heat, frequently shaking it. This may be diluted with one-fourth or one-fifth of alcohol. Metallic vessels or instruments, covered with two or three coats of this, and dried in an oven each time, may be washed with boiling water, or even exposed to a still greater heat, without injury to the varnish.

A varnish of the consistence of thin turpentine is obtained for aërostatic machines, by the digestion of one part of elastic gum, or caoutchouc, cut into small pieces, in thirty-two parts of rectified oil of turpentine. Previously to its being used, however, it must be passed through a linen cloth, in order that the undissolved parts may be left behind.

The third sort of lac-varnishes consists in the spirit-varnish. The most solid resins yield the most durable varnishes; but a varnish must never be expected to be harder than the resin naturally is of which it is made. Hence, it is the height of absurdity to suppose, that there are any incombustible varnishes, since there is no such thing as an incombustible resin. But the most solid resins by themselves produce brittle varnishes; therefore, something of a softer substance must always be mixed with them, whereby this brittleness is diminished. For this purpose gum-elemi, turpentine, or balsam of copaiva are employed in proper proportions. For the solution of these bodies the strongest alcohol ought to be used, which may very properly indeed be distilled over alkali, but must not have stood upon alkali. The utmost simplicity in composition with respect to the number of the ingredients in a formula is the result of the greatest skill in the art; hence it is no wonder, that the greatest part of the formulas and recipes that we meet with, are composed without any principle at all.

In conformity to these rules, a fine colourless varnish may be obtained, by dissolving eight ounces of gum-sandarach and two ounces of Venice turpentine in thirty-two ounces of alcohol by a gentle heat. Five ounces of shell-lac and one of turpentine, dissolved in thirty-two ounces of alcohol by a very gentle heat, give a harder varnish, but of a reddish cast. To these the solution of copal is undoubtedly preferable in many respects. This is effected by triturating an ounce of powder of gum-copal, which has been well dried by a gentle heat, with a drachm of camphor, and, while these are mixing together, adding by degrees four ounces of the strongest alcohol, without any digestion.

Between this and the gold-varnish there is only this difference, that some substances that communicate a yellow tinge are to be added to the latter. The most ancient description of two sorts of it, one of which was prepared with oil, and the other with alcohol, is to be found in Alexius Pedemontanus De i Secreti, Lucca, of which the first edition was published in the year 1557. But it is better prepared, and more durable, when made after the following prescription:——Take two ounces of shell-lac, of arnatto and turmeric of each one ounce, and thirty grains of fine dragon's-blood, and make an extract with twenty ounces of alcohol in a gentle heat.

Oil-varnishes are commonly mixed immediately with the colours, but lac or lacquer-varnishes are laid on by themselves upon a burnished coloured ground; when they are intended to be laid upon naked wood, a ground should be first given them of strong size, either alone or with some earthy colour, mixed up with it by levigation. The gold lacquer is simply rubbed over brass, tin, or silver, to give them a gold colour.

Before a resin is dissolved in a fixed oil, it is necessary to render the oil drying. For this purpose the oil is boiled with metallic oxides, in which operation the mucilage of the oil combines with the metal, while the oil itself unites with the oxygen of the oxide. To accelerate the drying of this varnish; it is necessary to add oil of turpentine.

The essential varnishes consist of a solution of resin in oil of turpentine. The varnish being applied, the essential oil flies off, and leaves the resin. This is used only for paintings.

When resins are dissolved in alcohol, the varnish dries very speedily, and is subject to crack; but this fault is corrected by adding a small quantity of turpentine to the mixture, which renders it brighter, and less brittle when dry.

The coloured resins or gums, such as gamboge, dragon's blood, &c. are used to colour varnishes.

To give lustre to the varnish after it is laid on, it is rubbed with pounded pumice-stone and water; which being dried with a cloth, the work is afterward rubbed with an oiled rag and tripoli. The surface is last of all cleaned with soft linen cloths, cleared of all greasiness with powder of starch, and rubbed bright with the palm of the hand.

Vegetable Kingdom. In the mineral kingdom, little of chemical operation takes place, wherein the peculiar locality or disposition of the principles which act upon each other, appears to have any considerable effect. The principles, for the most part simple, act upon each other by virtue of their respective attractions; if heat be developed, it is for the most part speedily conducted away; if elastic products be extricated, they in general make their escape;—in a word, we seldom perceive in the operations in the mineral kingdom, any arrangement, which at all resembles the artificial dispositions of the chemist.

But in the animal and vegetable kingdoms it is far otherwise. In the former of these, bodies are regularly changed by mechanical division, by digestion, and the application of peculiar solvents, in a temperature exceeding that of the atmosphere, and the whole of the effects are assisted, modified, and kept up by an apparatus for admitting the air of the atmosphere. The subjects of the vegetable kingdom possess undoubtedly a structure less elaborate. They exhibit much less of those energies, which are said to be spontaneous. The form of their vessels is much simpler, and, as far as we can perceive, their action is obedient to the changes of the atmosphere in quality and moisture, the mechanical action of winds, the temperature of the weather, and the influence of light. In these organized beings, the chemist discovers principles of a more compounded nature, than any which can be obtained from the mineral kingdom. These do not previously exist in the earth, and must therefore be results of vegetable life.

The most obvious difference between vegetables and animals is, that the latter are in general capable of conveying themselves from place to place; whereas vegetables, being fixed in the same place, absorb, by means of their roots and leaves, such support as is within their reach. This appears on the whole to consist of air and water. The greatest part of the support of animals are the products already elaborated in the vegetable kingdom. The products of these two kingdoms in the hands of the chemist are remarkably different, though perhaps not exclusively so. One of the most distinctive characters seems to be the presence of nitrogen or azotic gas, which may be extricated from animal substances by the application of nitric acid, and enters into the composition of the ammonia afforded by destructive distillation. It was long supposed, that ammonia was exclusively the product of the animal kingdom, but it is now well known, that certain plants likewise afford it.

When it is considered, that by far the greater part of every organized substance is capable of assuming the elastic form, and being volatilized by heat; that the products are during life brought into combination by slow and long-continued processes, and are kept separate from each other in the vessels of the plant or animal; that these combinations are liable to be altered by the destruction of those vessels, as well as by every notable change of temperature —it will not appear surprising, that the chemical analysis of plants should be in an imperfect state. See ANALYSIS.

In the structure of vegetables we observe the external covering or bark, the ligneous or woody matter, the vessels or tubes, and certain glandular or knotty parts. The comparative anatomy, and immediate uses of these parts, form an object of interesting research, but less immediately within the province of a chemical work.

The nutrition or support of plants appears to require water, earth, light, and air. There are various experiments, which have been instituted to show, that water is the only aliment, which the root draws from the earth. Van Helmont planted a willow, weighing fifty pounds, in a certain quantity of earth covered with sheet-lead; he watered it for five years with distilled water; and at the end of that time the tree weighed one hundred and sixty-nine pounds three ounces, and the earth in which it had vegetated was found to have suffered a loss of no more than three ounces. Boyle repeated the same experiment upon a plant, which at the end of two years weighed fourteen pounds more, without the earth in which it had vegetated having lost any perceptible portion of its weight.

Messrs. Duhamel and Bonnet supported plants with moss, and fed them with mere water: they observed, that the vegetation was of the most vigorous kind; and the naturalist of Geneva observes, that the flowers were more odoriferous, and the fruit of a higher flavour. Care was taken to change the supports before they could suffer any alteration. Mr. Tillet has likewise raised plants; more especially of the gramineous kind, in a similar manner, with this difference only, that his supports were pounded glass, or quartz in powder. Hales has observed, that a plant, which weighed three pounds, gained three ounces after a heavy dew. Do we not every day observe hyacinths and other bulbous plants, as well as gramineous plants, raised in saucers or bottles containing mere water? And Braconnot has lately found mustard-seed to germinate, grow, and produce plants, that came to maturity, flowered, and ripened their seed, in litharge, flowers of sulphur, and very small unglazed shot. The last appeared least favourable to the growth of the plants, apparently because their roots could not penetrate between it so easily.

All plants do not demand the same quantity of water; and nature has varied the organs of the several individuals conformably to the necessity of their being supplied with this food. Plants which transpire little, such as the mosses and the lichens, have no need of a considerable quantity of this fluid; and accordingly they are fixed upon dry rocks, and have scarcely any roots; but plants which require a larger quantity, have roots which extend to a great distance, and absorb humidity throughout their whole surface.

The leaves of plants have likewise the property of absorbing water, and of extracting from the atmosphere the same principle which the root draws from the earth. But plants which live in the water, and as it were swim in the element which serves them for food, have no need of roots; they receive the fluid at all their pores; and we accordingly find, that the fucus, the ulva, &c. have no roots whatever.

The dung, which is mixed with earths, and decomposed, not only affords the alimentary principles we have spoken of, but likewise favours the growth of the plant by that constant and steady heat, which its ulterior decomposition produces. Thus it is that Fabroni affirms his having observed the development of leaves and flowers in that part of a tree only, which was in the vicinity of a heap of dung.

From the preceding circumstances it appears, that the influence of the earth in vegetation is almost totally confined to the conveyance of water, and probably the elastic products from putrefying substances to the plant.

Vegetables cannot live without air. From the experiments of Priestley, Ingenhousz, and Sennebier, it is ascertained, that plants absorb the azotic part of the atmosphere; and this principle appears to be the cause of the fertility which arises from the use of putrefying matters in the form of manure. The carbonic acid is likewise absorbed by vegetables, when its quantity is small. If in large quantity, it is fatal to them.

Chaptal has observed, that carbonic acid predominates in the fungus, and other subterraneous plants. But by causing these vegetables, together with the body upon which they were fixed, to pass, by imperceptible gradations, from an almost absolute darkness, into the light, the acid very nearly disappeared; the vegetable fibres being proportionally increased, at the same time that the resin and colouring principles were developed, which he ascribes to the oxygen of the same acid. Sennebier has observed, that the plants which he watered with water impregnated with carbonic acid, transpired an extraordinary quantity of oxygen, which likewise indicates a decomposition of the acid.

Light is almost absolutely necessary to plants. In the dark they grow pale, languish, and die. The tendency of plants toward the light is remarkably seen in such vegetation as is effected in a chamber or place where the light is admitted on one side; for the plant never fails to grow in that direction. Whether the matter of light be condensed into the substance of plants, or whether it act merely as a stimulus or agent, without which the other requisite chemical processes cannot be effected, is uncertain.

It is ascertained, that the processes in plants serve, like those in animals, to produce a more equable temperature, which is for the most part above that of the atmosphere. Dr. Hunter, quoted by Chaptal, observed by keeping a thermometer plunged in a hole made in a sound tree, that it constantly indicated a temperature several degrees above that of the atmosphere, when it was below the fifty-sixth division of Fahrenheit; whereas the vegetable heat, in hotter weather, was always several degrees below that of the atmosphere. The same philosopher has likewise observed, that the sap which, out of the tree, would freeze at 32°, did not freeze in the tree unless the cold were augmented 15° more.

The vegetable heat may increase or diminish by several causes, of the nature of disease; and it may even become perceptible to the touch in very cold weather, according to Buffon.

The principles of which vegetables are composed, if we pursue their analysis as far as our means have hitherto allowed, are chiefly carbon, hydrogen, and oxygen. Nitrogen is a constituent principle of several, but for the most part in small quantity. Potash, soda, lime, magnesia, silex, alumina, sulphur, phosphorus, iron, manganese, and muriatic acid, have likewise been reckoned in the number; but some of these occur only occasionally, and chiefly in very small quantities; and are scarcely more entitled to be considered as belonging to them than gold, or some other substances, that have been occasionally procured from their decomposition.

The following are the principal products of vegetation:—

1. *Sugar.* Crystallizes. Soluble in water and alcohol. Taste sweet. Soluble in nitric acid, and yields oxalic acid.

2. *Sarcocol.* Does not crystallize. Soluble in water and alcohol. Taste bitter sweet. Soluble in nitric acid, and yields oxalic acid.

3. *Asparagin.* Crystallizes. Taste cooling and nauseous. Soluble in hot water. Insoluble in alcohol. Soluble in nitric acid, and converted into bitter principle and artificial tannin.

4. *Gum.* Does not crystallize. Taste insipid. Soluble in water, and forms mucilage. Insoluble in alcohol. Precipitated by silicated potash. Soluble in nitric acid, and forms mucous and oxalic acids.

5. *Ulmin.* Does not crystallize. Taste insipid. Soluble in water, and does not form mucilage. Precipitated by nitric and oxymuriatic acids in the state of resin. Insoluble in alcohol.

6. *Inulin.* A white powder. Insoluble in cold water. Soluble in boiling water; but precipitates unaltered after the solution cools. Insoluble in alcohol. Soluble in nitric acid, and yields oxalic acid.

7. *Starch.* A white powder. Taste insipid. Insoluble in cold water. Soluble in hot water; opaque and glutinous. Precipitated by an infusion of nutgalls; precipitate redissolved by a heat of 120°. Insoluble in alcohol. Soluble in dilute nitric acid, and precipitated by alcohol. With nitric acid yields oxalic acid and a waxy matter.

8. *Indigo*. A blue powder. Taste insipid. Insoluble in water, alcohol, ether. Soluble in sulphuric acid. Soluble in nitric acid, and converted into bitter principle and artificial tannin.

9. *Gluten*. Forms a ductile elastic mass with water. Partially soluble in water; precipitated by infusion of nutgalls and oxygenized muriatic acid. Soluble in acetic acid and muriatic acid. Insoluble in alcohol. By fermentation becomes viscid and adhesive, and then assumes the properties of cheese. Soluble in nitric acid, and yields oxalic acid.

10. *Albumen*. Soluble in cold water. Coagulated by heat, and becomes insoluble. Insoluble in alcohol. Precipitated by infusion of nutgalls. Soluble in nitric acid. Soon putrefies.

11. *Fibrin*. Tasteless. Insoluble in water and alcohol. Soluble in diluted alkalis, and in nitric acid. Soon putrefies.

12. *Gelatin*. Insipid. Soluble in water. Does not coagulate when heated. Precipitated by infusion of galls.

13. *Bitter principle*. Colour yellow or brown. Taste bitter. Equally soluble in water and alcohol Soluble in nitric acid. Precipitated by nitrate of silver.

14. *Extractive* Soluble in water and alcohol. Insoluble in ether. Precipitated by oxygenized muriatic acid, muriate of tin, and muriate of alumina; but not by gelatin. Dyes fawn colour.

15. *Tannin*. Taste astringent. Soluble in water and in alcohol of 0.810. Precipitated by gelatin, muriate of alumina, and muriate of tin.

16. *Fixed oils*. No smell. Insoluble in water and alcohol. Forms soaps with alkalis. Coagulated by earthy and metallic salts.

17. *Wax*. Insoluble in water. Soluble in alcohol, ether, and oils. Forms soap with alkalis. Fusible.

18. *Volatile oil*. Strong smell. Insoluble in water. Soluble in alcohol. Liquid. Volatile. Oily. By nitric acid inflamed, and converted into resinous substances.

19. *Camphor*. Strong odour. Crystallizes. Very little soluble in water. Soluble in alcohol, oils, acids. Insoluble in alkalis. Burns with a clear flame, and volatilizes before melting.

20. *Birdlime*. Viscid. Taste insipid. Insoluble in water. Partially soluble in alcohol. Very soluble in ether. Solution green.

21. *Resins*. Solid. Melt when heated. Insoluble in water. Soluble in alcohol, ether, and alkalis. Soluble in acetic acid. By nitric acid converted into artificial tannin.

22. *Guaiacum*. Possesses the characters of resins; but dissolves in nitric acid, and yields oxalic acid and no tannin.

23. *Balsams*. Possess the characters of the resins, but have a strong smell; when heated, benzoic acid sublimes. It sublimes also when they are dissolved in sulphuric acid. By nitric acid converted into artificial tannin.

24. *Caoutchouc*. Very elastic. Insoluble in water and alcohol. When steeped in ether reduced to a pulp, which adheres to every thing. Fusible, and remains liquid. Very combustible.

25. *Gum-resins*. Form milky solutions with water, transparent with alcohol. Soluble in alkalis. With nitric acid converted into tannin. Strong smell. Brittle, opaque, infusible.

26. *Cotton*. Composed of fibres. Tasteless. Very combustible. Insoluble in water, alcohol, and ether. Soluble in alkalis. Yields oxalic acid to nitric acid.

27. *Suber*. Burns bright, and swells. Converted by nitric acid into suberic acid and wax. Partially soluble in water and alcohol.

28. *Wood*. Composed of fibres. Tasteless. Insoluble in water and alcohol. Soluble in weak alkaline lixivium. Precipitated by acids. Leaves much charcoal when distilled in a red heat. Soluble in nitric acid, and yields oxalic acid.

* To the preceding we may add, emetin, fungin, hematin, nicotin, pollenin, the new vegetable alkalis, aconita, atropia, brucia, cicuta, datura, delphia, hyosciama, morphia, picrotoxia, strychnia, veratria; and the various vegetable acids, enumerated under the general article ACID.*

VEGETATION (SALINE). M. Chaptal has given us a good memoir on this subject, in the Journal de Physique, for October 1788, entitled Observations on the Influence of the Air and Light upon the Vegetation of Salts.

In the operations in the large way, of his manufactory of medical and chemical products, he often observed that salts, particularly the metallic, vegetated on the side most exposed to the light, and the frequency of the effect induced him to make some direct experiments on the subject. For this purpose he took several capsules of glass, and covered the half of each, as well above as below, with black silk. At the same time, he prepared solutions of almost all the earthy, alkaline, or metallic compound salts in distilled water, at the temperature of the atmosphere. These capsules were placed on tables in a well closed chamber, which had no chimney, and of which the doors and windows were carefully stopped up, in order that the evaporation might not be hastened by any agitation of the air. Reflected light, by which I understand the light from the clouds, was admitted through a small aperture in one of the window-shutters. By this management, as well as the disposition of the capsules, one-half of each of their respective cavities received light from the aperture, and the other was almost perfectly in darkness. The solutions were then carefully poured into the capsules by means of a funnel resting on the middle of the bottom, so that the border of the fluid was neat and uniform, without any irregularity or drop of the fluid falling on the bare surface of the glass.

Upwards of two hundred experiments were made, with variations of the principal trials, so as to leave no doubt with regard to the constancy of the results. The most remarkable fact is, that the vegetation took place on those surfaces only which were illuminated. This phenomenon was so striking in most of the solutions, that in the space of a few days, and frequently even within one single day, the salt was elevated several lines above the liquor upon the enlightened surface, while there did not appear the smallest crust or edge on the dark part. Nothing could be more interesting, than to observe this vegetation, projecting frequently more than an inch, and marking the line of distinction between the illuminated and dark parts of the vessel. The sulphates of iron, of zinc, and other metals, more especially presented this appearance. It was generally observed, that the vegetation was strongest toward the most enlightened part.

This phenomenon may be rendered still more interesting, by directing the vegetation at pleasure toward the different parts of the vessel. For this purpose, nothing more is required than to cover the several parts in succession. For the vegetation always takes place in the enlightened parts, and quickly ceases in that which is covered.

When the same solution has stood for several days, the insensible evaporation gradually depresses its surface, and a crust or edge of salt is left in the obscure part. But the salt never rises, or at least very imperfectly, above the liquor, and cannot be compared with the true vegetation.

When salts are suffered to vegetate in this manner, the spontaneous evaporation of the fluid affords very few crystals. All the saline matter extends itself on the sides of the vessel.

VEINS. The ores of metals are frequently found to fill certain clefts in mountains. These masses, when they run out in length, are called veins. Inconsiderable veins, which diverge from the principal, are called slips; and such masses of ore as are of considerable magnitude, but no great length, are called bellies, or stock-works.

***VERATRIA.** A new vegetable alkali, discovered lately by MM. Pelletier and Caventou, in the *veratrum sabatilla*, or cevadilla, the *veratrum album*, or white hellebore, and the *colchicum autumnale* or meadow saffron.

The seeds of cevadilla, after being freed from an unctuous and acid matter by ether, were digested in boiling alcohol. As this infusion cooled, a little wax was deposited; and the liquid being evaporated to an extract, redissolved in water, and again concentrated by evaporation, parted with its colouring matter. Acetate of lead was now poured into the solution, and an abundant yellow precipitate fell, leaving the fluid nearly colourless. The excess of lead was thrown down by sulphuretted hydrogen, and the filtered liquor being concentrated by evaporation, was treated with magnesia, and again filtered. The precipitate, boiled in alcohol, gave a solution, which, on evaporation, left a pulverulent matter, extremely bitter, and with decidedly alkaline characters. It was at first yellow, but by solution in alcohol, and precipitation by water, was obtained in a fine white powder.

The precipitate by the acetate of lead, gave, on examination, gallic acid; and hence it is concluded, that the new alkali existed in the seed as a gallate.

Veratria was found in the other plants above mentioned. It is white, pulverulent, has no odour, but excites violent sneezing. It is very acrid, but not bitter. It produced violent vomiting in very small doses, and, according to some experiments, a few grains may cause death. It is very little soluble in cold water. Boiling water dissolves about $\frac{1}{1000}$ part, and becomes acrid to the taste. It is very soluble in alcohol, and rather less soluble in ether. It fuses at 122° F., and then appears like wax. On cooling, it becomes an amber-coloured translucent mass. Heated more highly, it swells, decomposes, and burns. Decomposed by oxide of copper, it gave no trace of azote. It acts on test papers like an alkali, and forms salts uncrystallizable by evaporation. The salts appear like a gum. The supersulphate only seems to present crystals. Strong solutions of these salts are partially decomposed by water. Veratria falls down, and the solution becomes acid. The bisulphate appears to consist of

Veratria,	93.723	100
Sulphuric acid,	6.227	6.6441

The muriate is composed of,

Veratria,	95.8606	100
Muriatic acid,	4.1394	4.3181

Iodine and chlorine produce with veratria, an iodate, hydriodate, chloride, and muriate.

VERDIGRIS. A crude acetate of copper.

VERDITER, is a blue pigment, obtained by adding chalk or whiting to the solution of copper in aquafortis. Dr. Merret says, that it is prepared in the following manner: A quantity of whiting is put into a tub, and upon this the solution of the copper is poured. The mixture is to be stirred every day for some hours together, till the liquor loses its colour. The liquor is then to be poured off, and more solution of copper is to be added. This is to be repeated till the whiting has acquired the proper colour. Then it is to be spread on large pieces of chalk, and dried in the sun.

It appears from M. Pelletier's analysis, that 100 grains of the very best verditer contain, of carbonic acid 30, of water 3⅓, of pure lime 7, of oxygen 9⅔, and of pure copper 50. The author remarks, that the verditers of inferior quality contain more chalk and less copper.

Verjuice. A kind of harsh austere vinegar, made of the expressed juice of the wild apple or crab. The French give this name to unripe grapes, and to the sour liquor obtained from them.

Vermilion. The red sulphuret of mercury, or cinnabar.

Vessels (Chemical). See Apparatus.

* **Vesuvian.** *Idocrase* of Haüy; a subspecies of pyramidal garnet. Colours green and brown. Massive, disseminated, and crystallized. Primitive form, a pyramid of 129° 30′ and 74° 12′. The following secondary forms occur; a rectangular four-sided prism, variously acuminated, bevelled or truncated. The lateral planes of the prism are longitudinally streaked. Glistening vitreo-resinous. Cleavage imperfect, but in the direction of the diagonals. Fracture small grained uneven. Translucent. Refracts double. Scratches feldspar. Brittle. Sp. gr. 3.3 to 3.4. It becomes electrical by friction. Before the blow-pipe it melts without addition into a yellowish, and faintly translucent glass. Its constituents are, silica 35.5, lime 33, alumina 22.25, oxide of iron 7.5, oxide of manganese 0.25, loss 1.5.—*Klaproth.* It occurs in considerable abundance, in unaltered ejected rocks, in the vicinity of Vesuvius. The rare blue variety is found at Souland, in Tellemark, in Norway. At Naples it is cut into ring-stones.*

Vinegar. See Fermentation (Acetous); and also Acid (Acetic), where the mode of making it is given.

* **Vinegar from Wood.** M. Stolze, apothecary at Halle, has discovered a method of purifying vinegar from wood, by treating it with sulphuric acid, manganese, and common salt, and afterwards distilling it over.*

Vinegar of Saturn. Solution of acetate of lead.

Vinegar (Radical). Acetic acid.

Vital Air. See Oxygen.

Vitrification. See Glass; also Silica.

* **Vitriol,** *blue, green, red, white.* See Ores of Copper, Iron, Cobalt, Zinc.*

Vitriolic Acid. See Acid (Sulphuric.)

Volatile Alkali. See Ammonia.

Volatility. The property of bodies by which they are disposed to assume the vaporous or elastic state, and quit the vessels in which they are placed.

Volcanoes. The combustion of those enormous masses of bitumen, which are deposited in the bowels of the earth, produces volcanoes. They owe their origin more especially to the strata of pyritous coal. The decomposition or action of water upon the pyrities determines the heat, and the production of a great quantity of hydrogen, which exerts itself against the surrounding obstacles, and at length breaks them. This effect appears to be the chief cause of earthquakes; but when the concourse of air facilitates the combustion of the bitumen and the hydrogen, the flame is seen to issue out of the chimneys or vents which are made; and this occasions the fire of volcanoes.

There are many volcanoes still in an active state on our globe, independent of those of Italy, which are the most known. The Abbé Chappe has described three burning in Siberia. Anderson and Von Troil have described those of Iceland; Asia and Africa contain several; and we find the remains of these fires or volcanic products in all parts of the globe.

Naturalists inform us, that all the southern islands have been volcanized; and they are seen daily to be formed by the action of these subterraneous fires. The black colour of the stones, their spongy texture, the other products of fire, and the identity of these substances with those of the volcanoes at present burning, are all in favour of the opinion that their origin was the same.

When the decomposition of the pyrites is advanced, and the vapours and elastic fluids can no longer be contained in the bowels of the earth, the ground is shaken, and exhibits the phenomenon of earthquakes. Mephitic vapours are multiplied on the surface of the ground, and dreadful hollow noises are heard. In Iceland, the rivers and springs are swallowed up; a thick smoke, mixed with sparks and lightning, is then disengaged from the crater; and naturalists have observed, when the smoke of Vesuvius takes the form of a pine, the eruption is near at hand.

To these preludes, which show the internal agitation to be great, and that obstacles oppose the issue of the volcanic matters, succeeds an eruption of stones and other products, which the lava drives before it; and lastly, appears a river of lava, which flows out, and spreads itself down the side of the mountain. At this period the calm is restored in the bowels of the earth, and the eruption continues without earthquakes. The violent efforts of the included matter sometimes cause the sides of the mountain to open; and this is the cause which has successively formed the smaller mountains that surround volcanoes. Montenuevo, which is a hundred and eighty feet high, and three thousand in breadth, was formed in a night.

This crisis is sometimes succeeded by an eruption of ashes, which darken the air. These ashes are the last result of the alteration of the coals; and the matter which is first thrown out is that which the heat has half vitrified. In the year 1767, the ashes of Vesuvius were carried twenty leagues out to sea, and the streets of Naples were covered with them. The report of Dion, concerning the eruption of Vesuvius in the reign of Titus, wherein the ashes were carried into Africa, Egypt, and Syria, seems to be fabulous. M. de Saussure observes, that the soil of Rome is of this character, and that the famous catacombs are all made in the volcanic ashes.

It must be admitted, however, that the force with which all these products are thrown is astonishing. In the year 1769, a stone, twelve feet high and four in circumference, was thrown to the distance of a quarter of a mile from the crater: and in the year 1771 Sir William Hamilton observed stones of an enormous size, which employed eleven seconds in falling. This indicates an elevation of near two thousand feet.

The eruption of volcanoes is frequently aqueous: the water, which is confined, and favours the decomposition of the pyrites, is sometimes strongly thrown out. Sea salt is found among the ejected matter, and likewise sal ammoniac. In the year 1630, a torrent of boiling water, mixed with lava, destroyed Portici and Torre del Greco. Sir W. Hamilton saw boiling water ejected. The springs of boiling water in Iceland, and all the hot springs which abound at the surface of the globe, owe their heat only to the decomposition of pyrites.

Some eruptions are of a muddy substance; and these form the tuffa, and the pouzzolano. The eruption which buried Herculaneum is of this kind. Sir W. Hamilton found an antique head, the impression of which was well enough preserved to answer the purpose of a mould. Herculaneum at the least depth is seventy feet under the surface of the ground, and in many places one hundred and twenty.

The pouzzolano is of various colours. It is usually reddish, sometimes gray, white, or green: it frequently consists of pumice-stone in powder; but sometimes it is formed of oxided clay. One hundred parts of red pouzzolano afforded Bergmann, silex 55, alumina 20, lime 5, iron 20.

When the lava is once thrown out of the crater, it rolls in large rivers down the side of the mountain to a certain distance, which forms the currents of lava, the volcanic causeways &c. The surface of the lava cools, and forms a solid crust, under which the liquid lava flows. After the eruption, this crust sometimes remains, and forms hollow galleries, which Messrs. Hamilton and Ferber have visited; it is in these hollow places that the sal ammoniac, the muriate of soda, and other substances sublime. A lava may be turned out of its course by opposing banks or dykes against it: this was done in 1669 to save Catania; and Sir William Hamilton proposed it to the king of Naples to preserve Portici.

The currents of lava sometimes remain several years in cooling. Sir William Hamilton observed, in 1769, that the lav which flowed in 1766 was still smoking in some places.

Lava is sometimes swelled up and porous. The lightest is called *pumice-stone*.

The substances thrown out by volcanoes are not altered by fire. They eject native substances, such as quartz, crystals of amethyst, agate, gypsum, amianthus, feldspar, mica, shells, schörl, &c.

The fire of volcanoes is seldom strong enough to vitrify the matters it throws out. We know only of the yellowish capillary and flexible glass thrown out by the volcanoes of the island of Bourbon, on the 14th of May 1766, (M. Commerson), and the lapis gallinaceus ejected by Hecla. Mr. Egolfrigouson, who is employed by the observatory at Copenhagen, has settled in Iceland, where he uses a mirror of a telescope, which he has made out of the black agate of Iceland.

The slow operation of time decomposes lavas, and their remains are very proper for vegetation. The fertile island of Sicily has been every where volcanized. Chaptal observed several ancient volcanoes at present cultivated; and the line which separates the other earths from the volcanic earth, constitutes the limit of vegetation. The ground over the ruins of Pompeia is highly cultivated. Sir William Hamilton considers subterranean fires as the great vehicle used by nature to extract virgin earth out of the bowels of the globe, and repair the exhausted surface.

The decomposition of lava is very slow. Strata of vegetable earth, and pure lava, are occasionally found applied one over the other; which denote eruptions made at distances of time very remote from each other, since in some instances it appears to have required nearly two thousand years before lava was fit to receive the plough. In this respect, however, lavas differ very widely, so that our reasoning from them must at best be very vague. An argument has been drawn from this phenomenon to prove the antiquity of the globe: but the silence of the most ancient authors concerning the volcanoes of the kingdom of France, of which we find such frequent traces, indicates that these volcanoes have been extinguished from time immemorial; a circumstance which carries their existence to a very distant period. Beside this, several thousand years of connected observations have not afforded any remarkable change in Vesuvius or Ætna; nevertheless these enormous mountains are all volcanized, and consequently formed of strata applied one upon the other. The prodigy becomes much more striking, when we observe, that all the surrounding country, to very great distances, has been thrown out of the bowels of the earth.

The height of Vesuvius above the level of the sea is three thousand six hundred and fifty-nine feet; its circumference thirty-four thousand four hundred and forty-four. The height of Ætna is ten thousand and thirty-six feet; and its circumference one hundred and eighty thousand.

The various volcanic products are applicable to several uses.

1. The pouzzolano is of admirable use for building in the water: when mixed with lime it speedily fixes itself; and water does not soften it, for it becomes continually harder and harder. Chaptal has proved that oxided ochres afford the same advantage for this purpose; they are made into balls, and baked in a potter's furnace in the usual manner. The experiments made at Sette, by the commissary of the province, prove, that they may be substituted with the greatest advantage instead of the pouzzolano of Italy.

2. Lava is likewise susceptible of vitrification; and in this state it may be blown into opaque bottles of the greatest lightness, which Chaptal says he has done at Erepian and at Alais. The very hard lava, mixed in equal parts with wood-ashes and soda, produced, he says, an excellent green glass. The bottles made of it were only half the weight of common bottles, and much stronger, as was proved by Chaptal's experiments, and those which M. Joly de Fleury ordered to be made under his administration.

3. Pumice-stone likewise has its uses; it is more especially used to polish most bodies which are somewhat hard. It is employed in the mass or in powder, according to the intended purpose. Sometimes, after levigation, it is mixed with water to render it softer,

* Volcanite. Augite.*

* Vulpenite. Colour grayish-white. Massive. Splendent. Fracture foliated. Fragments rhomboidal. In distinct granular concretions. Translucent on the edges. Soft. Brittle. Sp. grav. 2.878. It melts easily before the blow-pipe into a white opaque enamel. Its constituents are, sulphate of lime 92, silica 8. It occurs along with granular foliated limestone at Vulpino, in Italy.*

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* Wacke. A mineral substance intermediate between clay and basalt. It is sometimes simple; but when it inclines to basalt, it contains hornblende and mica. It is sometimes spotted, and these spots are unformed crystals of hornblende, resembling the unformed crystals of feldspar in certain varieties of porphyry. It never contains augite or olivine. When it approaches to an amygdaloid, it is vesicular. Its colour is greenish-gray. Massive and vesicular. Dull. Opaque. Streak shining. Soft. Easily frangible. Sp. gr. 2.55 to 2.9. Fuses like basalt. It seldom contains petrifactions. It occurs sometimes in beds and veins, and these veins contain very small portions of ores of different kinds, as bismuth, silver-glance, and magnetic ironstone.*

Wadd. This name is given to plumbago, or black-lead.

Wadd Black. An ore of manganese found in Derbyshire. It is remarkable for the property of taking fire when mixed with linseed oil.

Wash. The technical term for the fermented liquor, of whatever kind, from which spirit is intended to be distilled. See Alcohol and Distillation.

Water. It is scarcely necessary to give any definition or description of this universally known fluid. It is a very transparent fluid, possessing a moderate degree of activity with regard to organized substances, which renders it friendly to animal and vegetable life, for both which it is indeed indispensably necessary. Hence it acts but slightly on the organs of sense, and is therefore said to have neither taste nor smell. It appears to possess considerable elasticity, and yields in a perceptible degree to the pressure of air in the condensing machine, as Canton proved, by including it in an open glass vessel with a narrow neck.

The solubility or insolubility of bodies in this fluid composes a large part of the science of chemistry. See SALT.

* The habitudes of water with heat have been detailed under *Caloric* and *Temperature.**

Water is not only the common measure of specific gravities, but the tables of these may be usefully employed in the admeasurement of irregular solids; for one cubic foot is very nearly equal to 1000 ounces avoirdupois. The numbers of the table denoting the specific gravities, do therefore denote likewise the number of ounces avoirdupois in a cubic foot of each substance.

Native water is seldom, if ever, found perfectly pure. The waters that flow within or upon the surface of the earth, contain various earthy, saline, metallic, vegetable, or animal particles, according to the substances over or through which they pass. Rain and snow waters are much purer than these, although they also contain whatever floats in the air, or has been exhaled along with the watery vapours.

The purity of water may be known by the following marks or properties of pure water:—

1. Pure water is lighter than water that is not pure.
2. Pure water is more fluid than water that is not pure.
3. It has no colour, smell, or taste.
4. It wets more easily than the waters containing metallic and earthy salts, called hard waters, and feels softer when touched.
5. Soap, or a solution of soap in alcohol, mixes easily and perfectly with it.
6. It is not rendered turbid by adding to it a solution of gold in aqua regia, or a solution of silver, or of lead, or of mercury, in nitric acid, or a solution of acetate of lead in water.

For the habitudes of water with saline matter, see SALT, and the different substances.

Water was, till modern times, considered as an elementary or simple substance.

Previous to the month of October 1776, the celebrated Macquer, assisted by M. Sigaud de la Fond, made an experiment by burning hydrogen gas in a bottle, without explosion, and holding a white china saucer over the flame. His intention appears to have been that of ascertaining whether any fuliginous smoke was produced, and he observes, that the saucer remained perfectly clean and white, but was moistened with perceptible drops of a clear fluid; resembling water; and which, in fact, appeared to him and his assistant, to be nothing but pure water. He does not say whether any test was applied to ascertain this purity, neither does he make any remark on the fact.§

In the month of September 1777, Messrs. Bucquet and Lavoisier, not being acquainted with the fact, which is incidentally and concisely mentioned by Macquer, made an experiment to discover what is produced by the combustion of hydrogen. They fired five or six pints of hydrogen in an open and wide-mouthed bottle, and instantly poured two ounces of lime-water through the flame, agitating the bottle during the time the combustion lasted. The result of this experiment showed, that carbonic acid was not produced.||

Before the month of April 1781, Mr. John Warltire, encouraged by Dr. Priestley, fired a mixture of common air and hydrogen gas in a close copper vessel, and found its weight diminished. Dr. Priestley, likewise, before the same period, fired a like mixture of hydrogen and oxygen gas in a closed glass vessel, Mr. Warltire being present. The inside of the vessel, though clean and dry before, became dewy, and was lined with a sooty substance.‡ These experiments were afterwards repeated by Mr. Cavendish and Dr. Priestley; and it was found, that the diminution of weight did not take place, neither was the sooty matter perceived.¶ These circumstances, therefore, must have arisen from some imperfection in the apparatus or materials with which the former experiments were made.

It was in the summer of the year 1781, that Mr. Henry Cavendish was busied in examining what becomes of the air lost by combustion, and made those valuable experiments, which were read before the Royal Society on the 15th of January 1784.§§ He burned 500,000 grain measures of hydrogen gas, with about 2½ times the quantity of common air, and by causing the burned air to pass through a glass tube eight feet in

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§ Dictionnaire de Chymie, 2d edition, Paris, 1778. Art. Gas Inflammable, vol. ii. p. 314, 315.

|| Acad. Par. 1781, p. 470.

‡ Priestley, v. 395.

¶ Phil. Trans. lxxiv. 126. Dr. Priestley supposed the sooty matter to be part of the mercury used in filling the vessel; Phil. Trans. lxxiv. 332.

§§ Mr. Lavoisier relates, that Dr. Blagden, Sec. R. S. (who was present at the performing of the capital experiment of burning hydrogen and oxygen gas in a closed vessel on the 24th June 1783,) informed him, that Mr. Cavendish had already done the same thing, and obtained water. See the Memoirs of the Royal Academy at Paris for 1781, p. 472; also Phil. Trans. vol. lxxiv. p. 134.

length, 135 grains of pure water were condensed. He also exploded a mixture of 19,500 grain measures of oxygen gas, and 37,000 of hydrogen, in a close vessel. The condensed liquor was found to contain a small portion of nitric acid, when the mixture of the air was such, that the burned air still contained a considerable proportion of oxygen. In this case it may be presumed, that some of the oxygen combines with a portion of nitrogen present.

In the mean time, M. Lavoisier continued his researches, and during the winter of 1781-1782, together with M. Gingembre, he filled a bottle of six pints with hydrogen, which being fired, and two ounces of lime-water poured in, was instantly stopped with a cork, through which a flexible tube communicating with a vessel of oxygen was passed. The inflammation ceased, except at the orifice of the tube, through which the oxygen was pressed, where a beautiful flame appeared. The combustion continued a considerable time, during which the lime-water was agitated in the bottle. Neither this, nor the same experiment repeated with pure water, and with a weak solution of alkali instead of lime-water, afforded the information sought after, for these substances were not at all altered.

The inference of Mr. Warltire, respecting the moisture on the inside of the glass, in which Dr. Priestley first fired hydrogen and common air, was, that these airs, by combustion, deposited the moisture they contained. Mr. Watt, however, inferred from these experiments, that water is a compound of the burned airs, which have given out their latent heat by combustion, and communicated his sentiments to Dr. Priestley in a letter dated April 26. 1783.§

It does not appear,|| that the composition of water was known or admitted in France, till the summer of 1783, when M. Lavoisier and M. de la Place, on the 24th of June, repeated the experiment of burning hydrogen and oxygen in a glass vessel over mercury, in a still greater quantity than had been burned by Mr. Cavendish. The result was nearly five gros of pure water.‡ M. Monge made a similar experiment at Paris, nearly at the same time, or perhaps before.

This assiduous and accurate philosopher then proceeded, in conjunction with M. Meusnier, to pass the steam of water through a red-hot iron tube, and found that the iron was oxidized, and hydrogen disengaged; and the steam of water being passed over a variety of other combustible or oxidable substances, produced similar results, the water disappearing, and hydrogen being disengaged. These capital experiments were accounted for by M. Lavoisier, by supposing the water to be decomposed into its component parts, oxygen and hydrogen, the former of which unites with the ignited substance, while the latter is disengaged.

The grand experiment of the composition of water by Fourcroy, Vauquelin, and Seguin, was begun on Wednesday, May 13, 1790, and was finished on Friday, the 22d of the same month. The combustion was kept up 185 hours with little interruption, during which time the machine was not quitted for a moment. The experimenters alternately refreshed themselves when fatigued, by lying for a few hours on mattresses in the laboratory.

To obtain the hydrogen, 1. Zinc was melted and rubbed into a powder in a very hot mortar. 2. This metal was dissolved in concentrated sulphuric acid diluted with seven parts of water. The air procured was made to pass through caustic alkali. To obtain the oxygen, two pounds and a half of crystallized hyperoxymuriate of potash were distilled, and the air was transferred through caustic alkali.

The volume of hydrogen employed was 25963.568 cubic inches, and the weight was 1039.358 grains.

The volume of oxygen was 12570.942, and the weight was 6209.869 grains.

The total weight of both elastic fluids was 7249.227.

The weight of water obtained was 7244 grains, or 12 ounces 4 gro[illegible]45 grains.

The weight of water which should have been obtained was 12 ounces 4 gros 49.227 grains.

The deficit was 4.227 grains.

The quantity of azotic air before the experiment was 415.256 cubic inches, and at the close of it 467. The excess after the experiment was consequently 51.744 cubic inches. This augmentation is to be attributed, the academicians think, to the small quantity of atmospheric air in the cylinders of the gasometers, at the time the other airs were introduced. These additional 51 cubic inches could not arise from the hydrogen, for experiment showed, that it contained no azotic air. Some addition of this last fluid, the experimenters think, cannot be avoided, on account of the construction of the machine.

The water being examined, was found to be as pure as distilled water. Its specific gravity to distilled water was as 18671: 18670.

* The decomposition of water is most

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§ Phil. Trans. vol. lxxiv. p. 330.

|| Compare Phil. Trans. vol. lxxiv. p. 138, with the Memoirs of the Royal Academy at Paris for 1781, pages 472 and 474.

‡ The ounce poids de marc being 472.2 grains troy, this quantity will be 295 English grains.

elegantly effected by ELECTRICITY; which see.

The composition of water is best demonstrated by exploding 2 volumes of hydrogen and 1 of oxygen, in the eudiometer. They disappear totally, and pure water results. A cubic inch of this liquid at 60°, weighs 252.52 grains, consisting of

28.06 grains hydrogen, and
224.46 " oxygen.

The bulk of the former gas is } 1325 cubic inches.
That of the latter is 662
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Hence there is a condensation of nearly two thousand volumes into one; and one volume of water contains 662 volumes of oxygen. The prime equivalent of water is 1.125; composed of a prime of oxygen = 1.0 + a prime of hydrogen = 0.125; or 9 parts by weight of water, consist of 8 oxygen + 1 hydrogen.*

WATER OF CRYSTALLIZATION. Many salts require a certain proportion of water to enable them to retain the crystalline form, and this is called their water of crystallization. Some retain this so feebly, that it flies off on exposure to the air, and they fall to powder. These are the efflorescent salts. Others have so great an affinity for water, that their crystals attract more from the air, in which they dissolve. These are the deliquescent.

WATERS (MINERAL). The examination of mineral waters with a view to ascertain their ingredients, and thence their medical qualities and the means of compounding them artificially, is an object of considerable importance to society. It is likewise a subject which deserves to be attended to, because it affords no mean opportunity for the agreeable practice of chemical skill. But this investigation is more especially of importance to the daily purposes of life, and the success of manufactures. It cannot but be an interesting object, to ascertain the component parts and qualities of the waters daily consumed by the inhabitants of large towns and vicinities. A very minute portion of unwholesome matter, daily taken, may constitute the principal cause of the differences in salubrity, which are observable in different places. And with regard to manufactures, it is well known to the brewer, the paper-maker, the bleacher, and a variety of other artists, of how much consequence it is to them, that this fluid should either be pure, or at least not contaminated with such principles as tend to injure the qualities of the articles they make. This analysis has accordingly employed the attention of the first chemists. Bergmann has written an express treatise on the subject, which may be found in the first volume of the English translation of his Essays. Kirwan published a valuable volume on the analysis of waters.

The topography of the place where these waters rise is the first thing to be considered. By examining the ooze formed by them, and the earth or stones through which they are strained and filtered, some judgment may be formed of their contents. In filtering through the earth, and meandering on its surface, they take with them particles of various kinds, which their extreme attenuation renders capable of being suspended in the fluid that serves for their vehicle. Hence we shall sometimes find in these waters, siliceous, calcareous, or argillaceous earth; and at other times, though less frequently, sulphur, magnesian earth, or, from the decomposition of carbonated iron, ochre.

The following are the ingredients that may occur in mineral waters:

1. Air is contained in by far the greater number of mineral waters: its proportion does not exceed 1-28th of the bulk of the water.

2. Oxygen gas was first detected in waters by Scheele. Its quantity is usually inconsiderable; and it is incompatible with the presence of sulphuretted hydrogen gas or iron.

3. Hydrogen gas was first detected in Buxton water by Dr. Pearson. Afterward it was discovered in Harrowgate waters by Dr. Garnet, and in those of Lemington Priors by Mr. Lambe.

4. Sulphuretted hydrogen gas constitutes the most conspicuous ingredient in those waters, which are distinguished by the name of hepatic or sulphureous.

The only acids hitherto found in waters, except in combination with a base, are the carbonic, sulphuric, and boracic.

5. Carbonic acid was first discovered in Pyrmont water by Dr. Brownrigg. It is the most common ingredient in mineral waters; 100 cubic inches of the water generally containing from 6 to 40 cubic inches of this acid gas. According to Westrumb, 100 cubic inches of Pyrmont water contain 187 cubic inches of it, or almost double its own bulk.

6. Sulphurous acid has been observed in several of the hot mineral waters in Italy, which are in the neighbourhood of volcanoes.

7. The boracic acid has also been observed in some lakes in Italy.

The only alkali which has been observed in mineral waters, uncombined, is soda; and the only earthy bodies are silex and lime.

8. Dr. Black detected soda in the hot mineral waters of Geysser and Rykum in Iceland; but in most other cases the soda is combined with carbonic acid.

9. Silex was first discovered in waters by

Bergmann, It was afterward detected in those of Geysser and Rykum by Dr. Black, and in those of Karlsbad by Klaproth. Hassenfratz observed it in the waters of Pougues, as Brezé did in those of Pu. It has been found also in many other mineral waters.

10. Lime is said to have been found uncombined in some mineral waters; but this has not been proved in a satisfactory manner.

The only salts hitherto found in mineral waters are the following sulphates, nitrates, muriates, carbonates, and borates; and of these the carbonates and muriates occur by far most commonly, and the borates and nitrates most rarely.

11. Sulphate of soda is not uncommon, especially in those mineral waters which are distinguished by the epithet *saline*.

12. Sulphate of ammonia is found in mineral waters near volcanoes.

13. Sulphate of lime is exceedingly common in water. Its presence seems to have been first detected by Dr. Lister in 1682.

14. Sulphate of magnesia is almost constantly an ingredient in those mineral waters which have purgative properties. It was detected in Epsom waters in 1610, and in 1696 Dr. Grew published a treatise on it.

15. Alum is sometimes found in mineral waters, but it is exceedingly rare.

16. Sulphate of iron occurs sometimes in volcanic mineral waters, and has even been observed in other places.

17. Sulphate of copper is only found in the waters which issue from copper mines.

18. Nitre has been found in some springs in Hungary, but it is exceedingly uncommon.

19. Nitrate of lime was first detected in water by Dr. Home, of Edinburgh, in 1756. It is said to occur in some springs in the sandy deserts of Arabia.

20. Nitrate of magnesia is said to have been found in some springs.

21. Muriate of potash is uncommon; but it has lately been discovered in the mineral springs of Uhleaborg in Sweden, by Julin.

22. Muriate of soda is so extremely common in mineral waters, that hardly a single spring has been analyzed without detecting some of it.

23. Muriate of ammonia is uncommon, but it has been found in some mineral springs in Italy and in Siberia.

24. Muriate of barytes is still more uncommon, but its presence in mineral waters has been announced by Bergmann.

25 and 26. Muriates of lime and magnesia are common ingredients.

27. Muriate of alumina has been observed by Dr. Withering, but it is very uncommon.

28. Muriate of manganese was mentioned by Bergmann as sometimes occurring in mineral waters. It has lately been detected by Lambe in the waters of Lemington Priors, but in an extremely limited proportion.

29. The presence of carbonate of potash in mineral waters has been mentioned by several chemists; if it do occur, it must be in a very small proportion.

30. Carbonate of soda is, perhaps, one of the most common ingredients of these liquids, if we except common salt and carbonate of lime.

31. Carbonate of ammonia has been discovered in waters, but it is uncommon.

32. Carbonate of lime is found in almost all waters, and is usually held in solution by an excess of acid. It appears from the different experiments of chemists, as stated by Mr. Kirwan, and especially from those of Berthollet, that water saturated with carbonic acid is capable of holding in solution 0.002 of carbonate of lime. Now water saturated with carbonic acid, at the temperature of 50°, contains very nearly 0.002 of its weight of carbonic acid. Hence it follows, that carbonic acid, when present in such quantity as to saturate waters, is capable of holding its own weight of carbonate of lime in solution. Thus we see 1000 parts by weight of water, when it contains two parts of carbonic acid, is capable of dissolving two parts of carbonate of lime. When the proportion of water is increased, it is capable of holding the carbonate of lime in solution, even when the proportion of carbonic acid united with it is diminished. Thus 24000 parts of water are capable of holding two parts of carbonate of lime in solution, even when they contain only one part of carbonic acid. The greater the proportion of water, the smaller proportion of carbonic acid is necessary to keep the lime in solution; and when the water is increased to a certain proportion, no sensible excess of carbonic acid is necessary. It ought to be remarked also, that water, however small a quantity of carbonic acid it contains, is capable of holding carbonate of lime in solution, provided the weight of the carbonic acid present exceed that of the lime. These observations apply equally to the other earthy carbonates held in solution by mineral waters.

33. Carbonate of magnesia is also very common in mineral waters, and is almost always accompanied by carbonate of lime.

34. Carbonate of alumina is said to have been found in waters, but its presence has not been properly ascertained.

35. Carbonate of iron is by no means uncommon; indeed it forms the most remarkable ingredient in those waters, which are distinguished by the epithet of *chalybeate*.

36. Borax exists in some lakes in Persia and Thibet, but the nature of these waters has not been ascertained.

37 and 38. The hydrosulphurets of lime and of soda have been frequently detected in those waters which are called sulphurous, or hepatic.

Mr. Westrumb says, that all sulphurous waters contain more or less hydrosulphuret of lime.

To detect this he boiled the mineral water, excluding the contact of atmospheric air, to expel the sulphuretted hydrogen gas and carbonic acid. Into the water thus boiled he poured sulphuric acid, when more sulphuretted hydrogen gas was evolved, and sulphate of lime was thrown down; fuming nitric acid, which separated from it sulphur; and oxalic acid, which expelled sulphuretted hydrogen, and formed oxalate of lime. The water evaporated in open vessels let fall sulphate of lime, and gave out sulphuretted hydrogen gas.

To ascertain the quantity of sulphuretted hydrogen gas and carbonic acid, Mr. Westrumb proceeded as follows: He introduced the sulphurous water into a matrass, till it was filled to a certain point, which he marked; fitted to it a curved tube, which terminated in a long cylinder; filled this cylinder with lime-water for the one experiment, and with acetate of lead, with excess of acid, for the other; luted the apparatus, and boiled the water till no more gas was expelled. When the lime-water is used, carbonate of lime is precipitated in the proportion of 20 grains to every 10 cubic inches of carbonic acid gas; when the solution of acetate of lead, hydrosulphuret of lead is thrown down in the proportion of 19 grains to 10 cubic inches of sulphuretted hydrogen gas.

Beside these substances, certain vegetable and animal matters have been occasionally observed in mineral waters. But in most cases, these are rather to be considered in the light of accidental mixtures, than of real component parts of the waters in which they occur.

From this synoptical view of the different ingredients contained in mineral waters, it is evident, that these substances occur in two different distinct states, viz. 1. As being suspended in them; and 2. As being dissolved in them chiefly in the form of a salt.

The investigation of mineral waters consists, 1. In the examination of them by the senses: 2. In the examination of them by reagents: 3. In the analysis properly so called.

The examination by the senses consists in observing the effect of the water as to appearance, smell, and taste.

The appearance of the water, the instant in which it is pumped out of the well, as well as after it has stood for some time, affords several indications, from which we are enabled to form a judgment concerning its contents. If the water be turbid at the well, the substances are suspended only, and not dissolved; but if the water be clear and transparent at the well, and some time intervenes before it becomes turbid, the contents are dissolved by means of carbonic acid.

The presence of this gas is likewise indicated by small bubbles, that rise from the bottom of the well, and burst in the air while they are making their escape, though the water at the same time perhaps has not an acid taste. This is the case, according to Count Razoumowski, with respect to the tepid spring in Vallais, and the cold vitriolated chalybeate springs at Astracan. But the most evident proof of a spring containing carbonic acid is the generation of bubbles on the water being shaken; and their bursting with more or less noise, while the air is making its escape.

The sediment deposited by the water in the well is likewise to be examined: if it be yellow, it indicates the presence of iron; if black, that of iron combined with sulphur; but chalybeate waters being seldom sulphuretted, the latter occurs very rarely. As to the colour of the water itself, there are few instances where this can give any indication of its contents, as there are not many substances that colour it.

The odour of the water serves chiefly to discover the presence of sulphuretted hydrogen in it: such waters as contain this substance have a peculiar fetid smell, somewhat resembling rotten eggs.

The taste of a spring, provided it be perfectly ascertained by repeated trials, may afford some useful indications with respect to the contents. It may be made very sensible by tasting water, in which the various salts that are usually found in such waters are dissolved in various proportions. There is no certain dependence, however, to be placed on this mode of investigation; for in many springs, the taste of sulphate of soda is disguised by that of the sea salt united with it. The water too is not only to be tasted at the spring, but after it has stood for some time. This precaution must be particularly observed with respect to such waters as are impregnated with carbonic acid; for the other substances contained in them make no impression on the tongue, till the carbonic acid has made its escape; and it is for the same reason, that these waters must be evaporated in part, and then tasted again.

Though the specific gravity of any water contributes but very little towards determining its contents, still it may not be entirely useless to know the specific weight of the water, the situation of the spring, and the kind of sediment deposited by it.

The examination of the water by means

of reagents shows what they contain, but not how much of each principle. In many instances this is as much as the inquiry demands; and it is always of use to direct the proceedings in the proper analysis.

It is absolutely necessary to make the experiment with water just taken up from the spring, and afterward with such as has been exposed for some hours to the open air; and sometimes a third essay is to be made with a portion of the water that has been boiled and afterward filtered. If the water contain but few saline particles, it must be evaporated; as even the most sensible reagents do not in the least affect it, if the salts, the presence of which is to be discovered by them, are diluted with too great a quantity of water. Now, it may happen, that a water shall be impregnated with a considerable number of saline particles of different kinds, though some of them may be present in too small a quantity; for which reason the water must be examined a second time, after having been boiled down to three-fourths.

The substances of which the presence is discoverable by reagents, are:—

1. Carbonic acid. When this is not combined with any base, or not with sufficient to neutralize it, the addition of lime-water will throw down a precipitate soluble with effervescence in muriatic acid. The infusion of litmus is reddened by it; but the red colour gradually disappears, and may be again restored by the addition of more of the mineral water. When boiled it loses the property of reddening the infusion of litmus. According to Pfaff, the most sensible test of this acid is acetate of lead.

2. The mineral acids, when present uncombined in water, give the infusion of litmus a permanent red, even though the water has been boiled. Bergmann has shown, that paper stained with litmus is reddened when dipped into water containing $\frac{1}{3521}$ of sulphuric acid.

3. Water containing sulphuretted hydrogen gas is distinguished by the following properties: It exhales the peculiar odour of sulphuretted hydrogen gas. It reddens the infusion of litmus fugaciously. It blackens paper dipped into a solution of lead, and precipitates the nitrate of silver black or brown.

4. Alkalis, and alkaline and earthy carbonates, are distinguished by the following tests: The infusion of turmeric, or paper stained with turmeric, is rendered brown by alkalis; or reddish-brown, if the quantity be minute. This change is produced when the soda in water amounts only to $\frac{1}{2217}$ part. Paper stained with Brazil wood, or the infusion of Brazil wood, is rendered blue; but this change is produced also by the alkaline and earthy carbonates. Bergmann ascertained, that water containing $\frac{1}{9948}$ part of carbonate of soda, renders paper stained with Brazil wood blue. Litmus paper reddened by vinegar is restored to its original blue colour. This change is produced by the alkaline and earthy carbonates also. When these changes are fugacious, we may conclude, that the alkali is ammonia.

5. Fixed alkalis exist in water that occasions a precipitate with muriate of magnesia after being boiled Volatile alkali may be distinguished by the smell; or it may be obtained in the receiver by distilling a portion of the water gently, and then it may be distinguished by the above tests.

6. Earthy and metallic carbonates are precipitated by boiling the water containing them; except carbonate of magnesia, which is precipitated but imperfectly.

7. Iron is discovered by the following tests:—The addition of tincture of galls gives water, containing iron, a purple or black colour. This test indicates the presence of a very minute portion of iron. If the tincture have no effect upon the water, after boiling, though it colours it before, the iron is in the state of a carbonate. The following observations of Westrumb on the colour which iron gives to galls, as modified by other bodies, deserve attention. A violet indicates an alkaline carbonate, or earthy salt. Dark purple indicates other alkaline salts. Purplish-red indicates sulphuretted hydrogen gas. Whitish, and then black, indicates sulphate of lime. Mr. Phillips has lately ascertained, that, while the iron is little oxided, the presence of lime rather facilitates the application of this test; but the lime prevents the test from acting, provided the iron be considerably oxidized. The prussian alkali occasions a blue precipitate in water containing iron. If an alkali be present, the blue precipitate does not appear unless the alkali is saturated with an acid.

8. Sulphuric acid exists in waters that form a precipitate with the following solutions:—muriate, nitrate, or acetate of barytes, strontian, or lime, or nitrate or acetate of lead. Of these the most powerful by far is muriate of barytes, which is capable of detecting the presence of sulphuric acid uncombined, when it does not exceed the millionth part of the water. Acetate of lead is next in point of power. The muriates are more powerful than the nitrates. The calcareous salts are least powerful. All these tests are capable of indicating a much smaller proportion of uncombined sulphuric acid, than when it is combined with a base. To render muriate of barytes a certain test of sulphuric acid, the following precautions must be observed:—The muriate must be diluted; the alkalis or alkaline carbonates, if the water contain any, must be previously sa-

turated with muriatic acid; the precipitate must be insoluble in muriatic acid; if boracic acid be suspected, muriate of strontian must be tried, which is not precipitated by boracic acid. The hydrosulphurets precipitate barytic solutions, but their presence is easily discovered by the smell.

9. Muriatic acid is detected by nitrate of silver, which occasions a white precipitate, or a cloud, in water containing an exceedingly minute portion of this acid. To render this test certain, the following precautions are necessary:—The alkalis or carbonates must be previously saturated with nitric acid. Sulphuric acid, if any be present, must be previously removed by means of nitrate of barytes. The precipitate must be insoluble in nitric acid. Pfaff says, that the mild nitrate of mercury is the most sensible test of muriatic acid; and that the precipitate is not soluble in an excess of any acid.

10. Boracic acid is detected by means of acetate of lead, with which it forms a precipitate insoluble in acetic acid. But to render this test certain, the alkalis and earths must be previously saturated with acetic acid, and the sulphuric and muriatic acids removed by means of acetate of strontian and acetate of silver.

11. Barytes is detected by the insoluble white precipitate, which it forms with diluted sulphuric acid.

12. Lime is detected by means of oxalic acid, which occasions a white precipitate in water containing a very minute proportion of this earth. To render this test decisive, the following precautions are necessary:—The mineral acids, if any be present, must be previously saturated with an alkali. Barytes, if any be present, must be previously removed by means of sulphuric acid. Oxalic acid precipitates magnesia but very slowly, whereas it precipitates lime instantly.

13. Magnesia and alumina. The presence of these earths is ascertained by the following tests:—Pure ammonia precipitates them both, and no other earth, provided the carbonic acid have been previously separated by a fixed alkali, and boiling. Lime-water precipitates only these two earths, provided the carbonic acid be previously removed, and the sulphuric acid also, by means of nitrate of barytes

The alumina may be separated from the magnesia, after both have been precipitated together, either by boiling the precipitate in caustic potash, which dissolves the alumina and leaves the magnesia; or the precipitate may be dissolved in muriatic acid, precipitated by an alkaline carbonate, dried in the temperature of 100°, and then exposed to the action of diluted muriatic acid, which dissolves the magnesia without touching the alumina.

14. Silex may be ascertained by evaporating a portion of water to dryness; and redissolving the precipitate in muriatic acid. The silex remains behind undissolved.

By these means we may detect the presence of the different substances commonly found in waters; but as they are generally combined so as to form salts, it is necessary we should know what these combinations are. This is a more difficult task, which Mr. Kirwan teaches us to accomplish by the following methods:—

1. To ascertain the presence of the different sulphates.

The sulphates which occur in water are seven; but one of these, namely, *sulphate of copper*, is so uncommon, that it may be excluded altogether. The same remark applies to sulphate of ammonia. It is almost unnecessary to observe, that no sulphate need be looked for, unless both its acid and base have been previously detected in the water.

Sulphate of soda may be detected by the following method:—Free the water to be examined of all earthy sulphates, by evaporating it to one-half, and adding lime-water as long as any precipitate appears. By these means the earths will all be precipitated except lime, and the only remaining earthy sulphate will be sulphate of lime, which will be separated by evaporating the liquid till it becomes concentrated, and then dropping into it a little alcohol, and, after filtration, adding a little oxalic acid.

With the water thus purified, mix solution of lime. If a precipitate appear, either immediately or on the addition of a little alcohol, it is a proof, that sulphate of potash or of soda is present. Which of the two may be determined, by mixing some of the purified water with acetate of barytes. Sulphate of barytes precipitates. Filter and evaporate to dryness. Digest the residuum in alcohol. It will dissolve the alkaline acetate. Evaporate to dryness, and the dry salt will deliquesce if it be acetate of potash, but effloresce if it be acetate of soda.

Sulphate of lime may be detected by evaporating the water suspected to contain it to a few ounces. A precipitate appears, which, if it be sulphate of lime, is soluble in 500 parts of water; and the solution affords a precipitate with the muriate of barytes, oxalic acid, carbonate of magnesia, and alcohol.

Alum may be detected by mixing carbonate of lime with the water suspected to contain it. If a precipitate appear, it indicates the presence of alum, or at least of sulphate of alumina; provided the water contains no muriate of barytes or metallic sulphates. The first of these salts is incompatible with alum. The second may be removed by the alkaline prussiates. When a precipitate is produced in water by muriate of lime, carbonate of lime, and muriate of magnesia, we may conclude, that it contains alum or sulphate of alumina.

Sulphate of magnesia may be detected by means of hydrosulphuret of strontian, which occasions an immediate precipitate with this salt, and with no other; provided the water be previously deprived of alum, if any be present, by means of carbonate of lime, and provided also that it contains no uncombined acid.

Sulphate of iron is precipitated from water by alcohol, and then it may be easily recognized by its properties.

2. To ascertain the presence of the different muriates.

The muriates found in waters amount to eight, or to nine, if muriate of iron be included. The most common by far is muriate of soda.

Muriate of soda and of potash may be detected by the following method:—Separate the sulphuric acid by alcohol and nitrate of barytes. Decompose the earthy nitrates and muriates by adding sulphuric acid. Expel the excess of muriatic and nitric acids by heat. Separate the sulphates thus formed by alcohol and barytes-water. The water thus purified can contain nothing but alkaline nitrates and muriates. If it form a precipitate with acetate of silver, we may conclude, that it contains muriate of soda or of potash. To ascertain which, evaporate the liquid thus precipitated to dryness. Dissolve the acetate in alcohol, and again evaporate to dryness. The salt will deliquesce, if it be acetate of potash; but effloresce, if it be acetate of soda.

Muriate of barytes may be detected by sulphuric acid, as it is the only barytic salt hitherto found in water.

Muriate of lime may be detected by the following method:—Free the water from sulphate of lime and other sulphates, by evaporating it to a few ounces, mixing it with alcohol, and adding last of all nitrate of barytes, as long as any precipitate appears. Filter the water; evaporate to dryness; treat the dry mass with alcohol; evaporate the alcohol to dryness; and dissolve the residuum in water. If this solution give a precipitate with acetate of silver and oxalic acid, it may contain muriate of lime. It must contain it in that case, if, after being treated with carbonate of lime, it give no precipitate with ammonia. If the liquid in the receiver give a precipitate with nitrate of silver, muriate of lime existed in the water.

Muriate of magnesia may be detected by separating all the sulphuric acid by means of nitrate of barytes. Filter, evaporate to dryness, and treat the dry mass with alcohol. Evaporate the alcoholic solution to dryness, and dissolve the residuum in water. The muriate of magnesia, if the water contained any, will be found in this solution: Let us suppose, that, by the tests formerly described, the presence of muriatic acid and of magnesia, in this solution, has been ascertained. In that case, if carbonate of lime afford no precipitate, and if sulphuric acid and evaporation, together with the addition of a little alcohol, occasion no precipitate, the solution contains only muriate of magnesia. If these tests give precipitates, we must separate the lime which is present by sulphuric acid and alcohol, and distil off the acid with which it was combined. Then the magnesia is to be separated by the oxalic acid and alcohol, and the acid with which it was united is to be distilled off. If the liquid in the retort give a precipitate with nitrate of silver, the water contains muriate of magnesia.

Muriate of alumina may be discovered by saturating the water, if it contain an excess of alkali, with nitric acid, and by separating the sulphuric acid by means of nitrate of barytes. If the liquid, thus purified, give a precipitate with carbonate of lime, it contains muriate of alumina. The muriate of iron or of manganese, if any be present, is also decomposed, and the iron precipitated by this salt. The precipitate may be dissolved in muriatic acid, and the alumina, iron, and manganese, if they be present, may be separated by the rules laid down below.

3. To ascertain the presence of the different nitrates. The nitrates but seldom occur in waters; but when they do, they may be detected by the following results:—

Alkaline nitrates may be detected by freeing the water examined from sulphuric acid by means of acetate of barytes, and from muriatic acid by acetate of silver. Evaporate the filtered liquid, and treat the dry mass with alcohol; what the alcohol leaves can consist only of the alkaline nitrates and acetate of lime. Dissolve it in water. If carbonate of magnesia occasion a precipitate, lime is present. Separate the lime by means of carbonate of magnesia. Filter and evaporate to dryness, and treat the dried mass with alcohol. The alcohol now leaves only the alkaline nitrates, which may be easily recognized, and distinguished by their respective properties.

Nitrate of lime. To detect this salt, concentrate the water, and mix it with alcohol to separate the sulphates. Filter, and distil off the alcohol; then separate the muriatic acid by acetate of silver. Filter, evaporate to dryness, and dissolve the residuum in alcohol. Evaporate to dryness, and dissolve the dry mass in water. If this last solution indicate the presence of lime by the usual tests, the water contained nitrate of lime.

To detect nitrate of magnesia, the water is to be freed from sulphates and muriates exactly as described in the last paragraph. The liquid thus purified is to be evaporated to dryness, and the residuum treated with alcohol. The alcoholic solution is to be evaporated to dryness, and the dry mass dissolved in water. To this solution potash is to be added, as long as any precipitate appears. The solution, filtered, and again evaporated to dryness, is to be treated with alcohol. If it leave a residuum consisting of nitre (the only residuum which it can leave) the water contained nitrate of magnesia.

Such are the methods by which the presence of the different saline contents of water may be ascertained. The labour of analysis may be considerably shortened, by observing that the following salts are incompatible with each other, and cannot exist together in water, except in very minute proportion:—

Salts.	Incompatible with
Fixed alkaline sulphates	Nitrates of lime and magnesia. Muriates of lime and magnesia.
Sulphate of lime	Alkalis, Carbonate of magnesia, Muriate of barytes.
Alum	Alkalis, Muriate of barytes, Nitrate, muriate, carbonate of lime, Carbonate of magnesia.
Sulphate of magnesia	Alkalis, Muriate of barytes, Nitrate and muriate of lime.
Sulphate of iron	Alkalis, Muriate of barytes, Earthy carbonates.
Muriate of barytes	Sulphates, Alkaline carbonates, Earthy carbonates.
Muriate of lime	Sulphates, except of lime, Alkaline carbonates, Earthy carbonates.
Muriate of magnesia	Alkaline carbonates, Alkaline sulphates.
Nitrate of lime	Alkaline carbonates, Carbonate of magnesia and alumina, Sulphates, except of lime,

Beside the substances above described, there is sometimes found in water a quantity of bitumen combined with alkali, and in the state of soap. In such waters, acids occasion a coagulation; and the coagulum collected on a filter discovers its bituminous nature by its combustibility.

Water also sometimes contains extractive matter; the presence of which may be detected by means of nitrate of silver. The water suspected to contain it must be freed from sulphuric and nitric acid by means of nitrate of lead: after this, if it give a brown precipitate with nitrate of silver, we may conclude that extractive matter is present.

But it is not sufficient to know that a mineral water contains certain ingredients; it is necessary to ascertain the proportions of these, and thus we arrive at their complete analysis.

1. The different aërial fluids ought to be first separated and estimated. For this purpose, a retort should be filled two-thirds with the water, and connected with a jar full of mercury, standing over a mercurial trough. Let the water be made to boil for a quarter of an hour. The aërial fluids will pass over into the jar. When the apparatus is cool, the quantity of air expelled from the water may be determined either by bringing the mercury within and without the jar to a level; or if this cannot be done, by reducing the air to the proper density by calculation. The air of the retort ought to be carefully subtracted, and the jar should be divided into cubic inches and tenths.

The only gaseous bodies contained in water are, common air, oxygen gas, nitrogen gas, carbonic acid, sulphuretted hydrogen gas, and sulphurous acid. The last two never exist in water together. The presence of either of them must be ascertained previously by the application of the proper tests. If sulphuretted hydrogen gas be present, it will be mixed with the air contained in the glass jar, and must be separated before this air be examined. For this purpose the jar must be removed into a tub of warm water, and nitric acid introduced, which will absorb the sulphuretted hydrogen. The residuum is then to be again put into a mercurial jar and examined.

If the water contain sulphurous acid, this previous step is not necessary. Introduce into the air a solution of pure potash, and agitate the whole gently. The carbonic acid and sulphurous acid gas will be absorbed, and leave the other gases. The bulk of this residuum, subtracted from the bulk of the whole, will give the bulk of the carbonic acid and sulphurous acid absorbed.

Evaporate the potash slowly, almost to dryness, and leave it exposed to the atmosphere. Sulphate of potash will be formed, which may be separated by dissolving the carbonate of potash by means of diluted muriatic acid, and filtering the solution. 100 grains of sulphate of potash indicate 36.4 grains of sulphurous acid, or 53.66 cubic inches of that acid in the state of gas. The bulk of sulphurous acid gas ascertained by this method, subtracted from the bulk of the gas absorbed by the potash, gives the bulk of the carbonic acid gas. Now 100 cubic inches of carbonic acid, at the temperature of 60° and barometer 30 inches, weigh 46.6 grains. Hence it is easy to ascertain its weight.

The gas remaining may be examined by the common eudiometrical processes.

When a water contains sulphuretted hydrogen gas, the bulk of this gas is to be ascertained in the following manner: Fill three-fourths of a jar with the water to be examined, and invert it in a water trough, and introduce a little nitrous gas. This gas, mixing with the air in the upper part of the jar, will form nitrous acid, which will render the water turbid, by decomposing the sulphuretted hydrogen and precipitating sulphur. Continue to add nitrous gas at intervals as long as red fumes appear, then turn up the jar and blow out the air. If the hepatic smell continue, repeat this process. The sulphur precipitated indicates the proportion of hepatic gas in the water; one grain of sulphur indicating the presence of nearly 3 cubic inches of this gas.

2. After having estimated the gaseous bodies, the next step is to ascertain the proportion of the earthy carbonates. For this purpose it is necessary to deprive the water of its sulphuretted hydrogen, if it contain any. This may be done, either by exposing it to the air for a considerable time, or treating it with litharge. A sufficient quantity of the water, thus purified if necessary, is to be boiled for a quarter of an hour, and filtered when cool. The earthy carbonates remain on the filter.

The precipitate thus obtained may be carbonate of lime, of magnesia, of iron, of alumina, or even sulphate of lime. Let us suppose all of these substances to be present together. Treat the mixture with diluted muriatic acid, which will dissolve the whole except the alumina and sulphate of lime. Dry this residuum in a red heat, and note the weight. Then boil it in carbonate of soda, saturate the soda with muriatic acid, and boil the mixture for half an hour. Carbonate of lime and alumina precipitate. Dry this precipitate and treat it with acetic acid. The lime will be dissolved, and the alumina will remain. Dry it, and weigh it. Its weight, subtracted from the original weight, gives the proportion of sulphate of lime.

The muriatic solution contains lime, magnesia, and iron. Add ammonia as long as a reddish precipitate appears. The iron and part of the magnesia are thus separated. Dry the precipitate, and expose it to the air for some time in a heat of 200°; then treat it with acetic acid to dissolve the magnesia; which solution is to be added to the muriatic solution. The iron is to be redissolved in muriatic acid, precipitated by an alkaline carbonate, dried and weighed.

Add sulphuric acid to the muriatic solution as long as any precipitate appears; then heat the solution and concentrate. Heat the sulphate of lime thus obtained to redness, and weigh it. 100 grains of it are equivalent to 74.7 of carbonate of lime dried. Precipitate the magnesia by means of carbonate of soda. Dry it and weigh it. But as part remains in solution, evaporate to dryness, and wash the residuum with a sufficient quantity of distilled water, to dissolve the muriate of soda and sulphate of lime, if any be still present. What remains behind is carbonate of magnesia. Weigh it, and add its weight to the former. The sulphate of lime, if any, must also be separated and weighed.

3. We have next to ascertain the proportion of mineral acids or alkalis, if any be present uncombined. The acids which may be present, omitting the gaseous, are the sulphuric, muriatic, and boracic.

The proportion of sulphuric acid is easily determined. Saturate it with barytes-water, and ignite the precipitate. 100 grains of sulphate of barytes thus formed indicate 34.0 of real sulphuric acid.

Saturate the muriatic acid with barytes-water and then precipitate the barytes by sulphuric acid. 100 parts of the ignited precipitate are equivalent to 23.73 grains of real muriatic acid.

Precipitate the boracic acid by means of acetate of lead. Decompose the borate of lead by boiling it in sulphuric acid. Evaporate to dryness. Dissolve the boracic acid in alcohol, and evaporate the solution; the acid left behind may be weighed.

To estimate the proportion of alkaline carbonate present in a water containing it, saturate it with sulphuric acid, and note the weight of real acid necessary. Now 100 grains of real sulphuric acid saturate 120.0 potash, and 80.0 soda.

4. The alkaline sulphates may be estimated by precipitating their acid by means of nitrate of barytes, having previously freed the water from all other sulphates; for 14.75 grains of ignited sulphate of barytes indicate 9.0 grains of dried sulphate of soda; while 14.75 sulphate of barytes indicate 11 of dry sulphate of potash.

Sulphate of lime is easily estimated by evaporating the liquid containing it to a few ounces (having previously saturated the earthy carbonates with nitric acid), and precipitating the sulphate of lime by means of weak alcohol. It may then be dried and weighed.

The quantity of alum may be estimated by precipitating the alumina by carbonate of lime or of magnesia (if no lime be present in the liquid). Eleven grains of the alumina, heated to incandescence, indicate 100 of crystallized alum, or 55 of dried salt.

Sulphate of magnesia may be estimated, provided no other sulphate be present, by precipitating the acid by means of a barytic salt, as 14.75 parts of ignited sulphate of barytes indicate 7.46 of sulphate of magnesia. If sulphate of lime, and no other sulphate, accompany it, this may be decomposed, and the lime precipitated by carbonate of magnesia. The weight of the lime thus obtained, enables us to ascertain the quantity of sulphate of lime contained in the water. The whole of the sulphuric acid is then to be precipitated by barytes. This gives the quantity of sulphuric acid; and subtracting the portion which belongs to the sulphate of lime, there remains that which was combined with the magnesia, from which the sulphate of magnesia may be easily estimated.

If sulphate of soda be present, no earthy nitrate or muriate can exist. Therefore, if no other earthy sulphate be present, the magnesia may be precipitated by soda, dried and weighed; 2.46 grains of which indicate 7.46 grains of dried sulphate of magnesia. The same process succeeds when sulphate of lime accompanies these two sulphates; only in this case the precipitate, which consists both of lime and magnesia, is to be dissolved in sulphuric acid, evaporated to dryness, and treated with twice its weight of cold water, which dissolves the sulphate of magnesia, and leaves the other salt. Let the sulphate of magnesia be evaporated to dryness, exposed to a heat of 400°, and weighed. The same process succeeds, if alum be present instead of sulphate of lime. The precipitate in this case, previously dried, is to be treated with acetic acid, which dissolves the magnesia, and leaves the alumina. The magnesia may be again precipitated, dried and weighed. If sulphate of iron be present, it may be separated by exposing the water to the air for some days, and mixing with it a portion of alumina. Both the oxide of iron, and the sulphate of alumina, thus formed, precipitate in the state of an insoluble powder. The sulphate of magnesia may then be estimated by the rules above given.

Sulphate of iron may be estimated by precipitating the iron by means of prussic alkali, having previously determined the weight of the precipitate produced by the prussiate in a solution of a given weight of sulphate of iron in water. If muriate of iron be also present, which is a very rare case, it may be separated by evaporating the water to dryness, and treating the residuum with alcohol, which dissolves the muriate, and leaves the sulphate.

5. If muriate of potash or of soda, without any other salt, exist in water, we have only to decompose them by nitrate of silver, and dry the precipitate; for 18.2 of muriate of silver indicate 9.5 of muriate of potash; and 18.2 of muriate of silver indicate 7.5 of common salt.

The same process is to be followed, if the alkaline carbonates be present; only these carbonates must be previously saturated with sulphuric acid; and we must precipitate the muriatic acid by means of sulphate of silver instead of nitrate. The presence of sulphate of soda does not injure the success of this process.

If muriate of ammonia accompany either of the fixed alkaline sulphates, without the presence of any other salt, decompose the sal ammoniac by barytes-water, expel the ammonia by boiling, precipitate the barytes by diluted sulphuric acid, and saturate the muriatic acid with soda The sulphate of barytes thus precipitated, indicates the quantity of muriate of ammonia; 14.75 grains of sulphate indicating 67.0 grains of this salt. If any sulphate be present in the solution, they ought to be previously separated.

If common salt be accompanied by muriate of lime, muriate of magnesia, muriate of alumina, or muriate of iron, or by all these together, without any other salt, the earths may be precipitated by barytes-water, and redissolved in muriatic acid. They are then to be separated from each other by the rules formerly laid down, and their weight, being determined, indicates the quantity of every particular earthy muriate contained in the water. For 50 grains of lime indicate 100 of dried muriate of lime; 30 grains of magnesia indicate 100 of the muriate of that earth; and 21.8 grains of alumina indicate 100 of the muriate of alumina. The barytes is to be separated from the solution by sulphuric acid, and the muriatic acid expelled by heat, or saturated with soda; the common salt may then be ascertained by evaporation; subtracting in the last case the proportion of common salt indicated by the known quantity of muriatic acid, from which the earths had been separated.

When sulphates and muriates exist together, they ought to be separated either by precipitating the sulphates by means of alcohol, or by evaporating the whole to dryness, and dissolving the earthy muriates in alcohol. The salts thus separated may be estimated by the rules already laid down.

When alkaline and earthy muriates and sulphate of lime occur together, the last is to be decomposed by means of muriate of barytes. The precipitate ascertains the weight of sulphate of lime contained in the water. The estimation is then to be conducted as when nothing but muriates are present; only from the muriate of lime, that proportion of muriate must be deducted, which is known to have been formed by the addition of the muriate of barytes.

When muriates of soda, magnesia, and alumina are present; together with sulphates of lime and magnesia, the water to be examined ought to be divided into two equal portions. To the one portion add carbonate of magnesia, till the whole of the lime and alumina is precipitated. Ascertain the quantity of lime, which gives the proportion of sulphate of lime. Precipitate the sulphuric acid by muriate of barytes. This gives the quantity contained in the sulphate of magnesia and sulphate of lime; subtracting this last portion, we have the quantity of sulphate of magnesia.

From the second portion of water, precipitate all the magnesia and alumina by means of lime-water. The weight of these earths enables us to ascertain the weight of muriate of magnesia and of alumina contained in the water, subtracting that part of the magnesia which existed in the state of sulphate, as indicated by the examination of the first portion of water. After this estimation, precipitate the sulphuric acid by barytes-water, and the lime by carbonic acid. The liquid, evaporated to dryness, leaves the common salt.

6. It now only remains to explain the method of ascertaining the proportion of the nitrates which may exist in waters.

When nitre accompanies sulphates and muriates without any other nitrates, the sulphates are to be decomposed by acetate of barytes, and the muriates by acetate of silver. The water, after filtration, is to be evaporated to dryness, and the residuum treated with alcohol, which dissolves the acetates, and leaves the nitre, the quantity of which may be easily calculated. If an alkali be present, it ought to be previously saturated with sulphuric or muriatic acid.

If nitre, common salt, nitrate of lime, and muriate of lime or magnesia, be present together, the water ought to be evaporated to dryness, and the dry mass treated with alcohol, which takes up the earthy salts. From the residuum, redissolved in water, the nitre may be separated, and calculated as in the last case. The alcoholic solution is to be evaporated to dryness, and the residuum redissolved in water. Let us suppose it to contain muriate of magnesia, nitrate of lime, and muriate of lime. Precipitate the muriatic acid by nitrate of silver, which gives the proportion of muriate of magnesia and of lime. Separate the magnesia by means of carbonate of lime, and note its quantity. This gives the quantity of muriate of magnesia; and subtracting the muriatic acid contained in that salt from the whole acid indicated by the precipitate of silver, we have the proportion of muriate of lime. Lastly, saturate the lime added to precipitate the magnesia with nitric acid. Then precipitate the whole of the lime by sulphuric acid; and subtracting from the whole of the sulphate thus formed, that portion formed by the carbonate of lime added, and by the lime contained in the muriate, the residuum gives us the lime contained in the original nitrate; and 35 grains of lime form 100 of dry nitrate of lime.

* In the year 1807, Dr. Marcet advanced some new ideas on the art of analyzing mineral waters, in an admirable paper on the water of the Dead Sea, inserted in the Phil. Transactions. "It is satisfactory to observe," says this excellent chemist, "that Dr. Murray adopted, several years afterwards, a mode of proceeding precisely similar, and indeed that he proposed, in a subsequent paper, a general formula for the analysis of mineral waters, in which this method is pointed out, as likely to lead to the most accurate results. And this coincidence is the more remarkable, as it would appear from Dr. Murray not mentioning my labours, that they had not at that time come to his knowledge." Phil. Trans. 1819. part ii.

The following table exhibits the compositions of the principal mineral waters, as well as that of the sea. The reader will find in the Phil. Trans. for 1819, a very valuable dissertation on sea-water, by Dr. Marcet, of which a good abstract is given in the 2d volume of the Edin. Phil. Journal. This philosopher shows, that in Baffin's-Bay, the Mediterranean Sea, and the Tropical Seas, the *temperature* of the sea *diminishes* with the depth, according to the observations of Phipps, Ross, Parry, Sabine, Saussure, Ellis, and Peron; but that in the Arctic or Greenland Seas, the *temperature* of the sea *increases* with the depth. This singular result was first obtained by Mr. Scoresby, in a series of well conducted experiments, and has been confirmed by the later observations of Lieutenants Franklin and Beechy, and Mr. Fisher.*

* *TABLE of the Composition of the most celebrated Mineral Waters.*

	Names of the Springs.	Grains of water.	Cubic inches of gases.				Carbonates of				Sulphates of				Muriates of				Silica.	Alumina.	Resins.	Temperature.
			Oxygen.	Carbonic acid.	Sulph. hydrogen.	Azote.	Soda.	Lime.	Magnesia.	Iron.	Soda.	Lime.	Magnesia.	Iron.	Soda.	Lime.	Magnesia.	Potash.				
							gr.	gr.	gr.	gr.	gr.	gr.	gr.	gr.	gr.	gr.	gr.	gr.	gr.	gr.	gr.	
Acidulous.	Seltzer (1)	8949	43.5	13.068			5.22	78.3	6.32						13.74							cold
	Pyrmont (1)	8050		19.6				4.3	9.8.	0.70		8.38	5.44		1.7							cold
	Spa (1)	8933		9.8			1.85	1.85	4.35	0.70					0.21							cold
	Carlsbad (2)	25320		50.0			38.5	12.5		0.1 1-4	66.75				32.5				2.25			65°
	Kilburn (10)	138240		84.0	36.0			2.4	1.25	0.3 1-4	18.2	13.0	91.0		6.0	0.6	2.8				6.0	cold
Sulphurous.	Harrowgate (14)	103643		8.0	19.0	7.0		18.5	5.5				0.5		615.5	3.0	9.1					cold
	Moffat (14)	103643		1.0	10.0	4.0									3.6							cold
	Aix-la-Chapelle (3)	8940			13.06			15.25	5.89						6.21							143°
	Enghien (5)	92160		18.5	7.0			21.4	1.35			33.3	5.8		2.4		8.0					cold
Saline.	Sedlitz	58309		8.0				6.7	21.0			41.1	1444				36.5					cold
	Cheltenham (6)	103643		30.3	3.0	12.0			12.5	5.0	48.0	40.			5.0		12.5					cold
	Plombieres (20)	14600					36.	0.4			1.0				2.0							cold
	Dunblane (16) sp.gr. 1.00475	7291						0.5		0.17	3.7				21.	20.8						cold
	Pitcaithly (16)	7291		1.				0.5			0.9				12.7	20.2						cold
Chalybeate.	Tunbridge (3)	103643	1.4	10.6		4.0				1.0		1.25			0.5		2.25					cold
	Brighton (4)	58309		18.0								32.7		11.2	12.2		6.0		1.12			cold
	Toplitz (7)	22540					13.5	16.5		32.5					61.3	28.5				15.1		cold
Calcareous, nearly pure.	Bath (8)	15360		2.4				1.6		0.004	3.0	18.0			6.6				0.4			114°
	Buxton (9)	58309				2.0		10.5				2.5			1.5							82°
	Bristol (11)	58309		30.3				13.5			11.2	11.7			4.0		7.25					74°
	Matlock	58309										trace										66°
	Malvern (15)	58309					5.33	1.6	0.92	.625	2.896				1.55							cold
	Dead Sea (17) sp. gr. 1.211	100										.054			10.676	3.8	10.1					
	Do. (18) sp. gr. 1.245														7.8	10.6	24.2					
	Do. (19) sp. gr. 1.2283														6.95	4.0	15.31					
	Sea water, Forth (16)	7291									25.6				159.3	5.7	35.5	trace.†				

(1) Bergmann. (2) Klaproth. (3) Babbington. (4) Marcet. (5) Fourcroy. (6) Fothergill. (7) John.
(8) Phillips. (9) Pearson. (10) Schmeisser. (11) Carrick. (14) Garnet. (15) Dr. Philip. (16) Dr. Murray.
(17) Dr. Marcet. (18) Klaproth. (19) M. Gay-Lussac. (20) Vauquelin. † Dr. Wollaston.

* **Water (Oxygenized)**, or deutoxide of hydrogen. This interesting compound has been lately formed by M. Thenard, and an account of it published in the tenth volume of the Annales de Chimie et Physique. The deutoxide of barium being dissolved in water, and sulphuric acid added, the protoxide of barium or barytes falls down, leaving the oxygen combined with the water. It contains, at 32 degrees Fahrenheit when saturated, twice the quantity of oxygen of common water; that is to say, a cubic inch absorbs 662 cubic inches = 224.46 gr. forming 476.98 grains, and acquires a specific gravity of 1.453. Hence 1.0 in volume, becomes apparently 1.3; containing 1324 volumes of oxygen; and 1 therefore contains very nearly 1000 volumes.

In consequence of this great density, when it is poured into common water, we see it fall down through that liquid like a sort of sirup, though it is very soluble in it. It attacks the epidermis almost instantly, and produces a prickling pain, the duration of which varies, according to the quantity of the liquid applied to the skin. If this quantity be too great, or if the liquid be renewed, the skin itself is attacked and destroyed. When applied to the tongue, it whitens it also, thickens the saliva, and produces in the organs of taste a sensation difficult to express, but one which approaches to that of tartar emetic. Its action on oxide of silver is exceedingly violent. Every drop of the liquid let fall on the dry oxide, produces a real explosion; and so much heat is evolved, that if the experiment be made in a dark place, there is a very sensible disengagement of light. Besides the oxide of silver, there are several other oxides, which act with violence on oxygenated water; for example the peroxide of manganese, that of cobalt, the oxides of lead, platinum, gold, iridium, rhodium, palladium. Several metals in a state of extreme division, occasion the same phenomenon; such as silver, platinum, gold, osmium, iridium, rhodium, palladium. In all the preceding cases, it is always the oxygen united to the water, which is disengaged, and sometimes likewise that of the oxide; but in others, a portion of the oxygen unites with the metal itself. This is the case when arsenic, molybdenum, tungsten, or selenium is employed. These metals are often acidified with the production of light.

The acids render the oxygenated water more stable. Gold in a state of extreme division acts with great force on pure oxygenated water; yet it has no action on that liquid, if it be mixed with a little sulphuric acid.

M. Thenard took pure oxygenated water, and diluted it, so that it contained only 8 times its volume of oxygen. He passed 22 measures of it into a tube filled with mercury. He then introduced a little fibrin, quite white, and recently extracted from blood. The oxygen began instantly to be disengaged from the water; the mercury in the tube sunk; at the end of six minutes the water was completely disoxygenated; for it no longer effervesced with oxide of silver. Having then measured the gas disengaged, he found it 176 measures = 8 + 22, that is to say, as much as the liquid contained. This gas contained neither carbonic acid nor azote. It was pure oxygen. The same fibrin placed in contact with new portions of oxygenated water, acted in the same manner.

Urea, albumen, liquid or solid, and gelatin, do not disengage oxygen from water, even very much oxygenated. But the tissue of the lungs cut into thin slices, and well washed; that of the kidneys and the spleen, drive the oxygen out of the water, with as much facility, at least, as fibrin does. The skin and the veins possess the same property, but in a weaker degree. These results are equally interesting and mysterious. For a valuable application of oxygenated water, see Paints.*

* **Wavellite.** Colour grayish-white. Imitative and crystallized, in very oblique four-sided prisms, flatly bevelled on the extremities, or truncated on the obtuse lateral edges. Shining, pearly. Fragments wedge-shaped. Translucent. As hard as fluor spar. Brittle. Sp. gr. 2.3 to 2.8. Its constituents are, alumina 70, lime 1.4, water 26.2.—*Davy.* It is said to contain also a small quantity of fluoric acid. It occurs in veins along with fluor spar, quartz, tin-stone, and copper pyrites in granite, at St. Austle in Cornwall. At Barnstable in Devonshire, where it was first found by Dr. Wavell, it traverses slate-clay, in the form of small contemporaneous veins. It has been found in rocks of slate-clay, near Loch Humphrey, Dumbartonshire.*

Wax is an oily concrete matter gathered by bees from plants. Proust says, that the bloom on fruit is real wax; and that it is wax spread over leaves, which prevents them from being wetted, as on the cabbage-leaf. He likewise finds it in the fecula of some vegetables, particularly in that of the small house-leek, in which it abounds. Huber, however, asserts, from his observations, that the wax in bee-hives is an artificial production, made by the bees from honey; that they cannot procure it, unless they have honey or sugar for the purpose; and that raw sugar affords more than honey.

It was long considered as a resin, from

some properties common to it with resins. Like them, it furnishes an oil and an acid by distillation, and is soluble in all oils; but in several respects it differs sensibly from resins. Like these, wax has not a strong aromatic taste and smell, but a very weak smell, and when pure, no taste. With the heat of boiling water, no principles are distilled from it; whereas, with that heat, some essential oil, or at least a spiritus rector, is obtained from every resin. Farther, wax is less soluble in alcohol. If wax be distilled with a heat greater than that of boiling water, it may be decomposed, but not so easily as resins can. By this distillation a small quantity of water is first separated from the wax, and then some very volatile and very penetrating acid, accompanied by a small quantity of a very fluid and very odoriferous oil. As the distillation advances, the acid becomes more and more strong, and the oil more and more thick, till its consistence is such, that it becomes solid in the receiver, and is then called butter of wax. When the distillation is finished, nothing remains but a small quantity of coal, which is almost incombustible.

Wax cannot be kindled, unless it is previously heated and reduced into vapours; in which respect it resembles fat oils. The oil and butter of wax may by repeated distillations be attenuated and rendered more and more fluid, because some portion of acid is thereby separated from these substances; which effect is similar to what happens in the distillation of other oils and oily concretes: but this remarkable effect attends the repeated distillation of oil and butter of wax, that they become more and more soluble in alcohol; and that they never acquire greater consistence by evaporation of their more fluid parts. Boerhaave kept butter of wax in a glass vessel open, or carelessly closed, during twenty years, without acquiring a more solid consistence. It may be remarked, that wax, its butter, and its oil, differ entirely from essential oils and resins in all the above mentioned properties, and that in all these they perfectly resemble sweet oils. Hence Macquer concludes, that wax resembles resins only in being an oil rendered concrete by an acid; but that it differs essentially from these in the kind of the oil, which in resins is of the nature of essential oils, while in wax and in other analogous oily concretions (as butter of milk, butter of cocoa, fat of animals, spermaceti, and myrtle-wax) it is of the nature of mild, unctuous oils, that are not aromatic, and not volatile, and are obtained from vegetables by expression.

It seems probable, that the acidifying principle, or oxygen, and not an actual acid, may be the leading cause of the solidity, or low fusibility of wax. Wax is very useful, especially as a better material than any other for candles.

Wax may be deprived of its natural yellow disagreeable colour, and be perfectly whitened by exposure to the united action of air and water, by which method the colour of many substances may be destroyed.

The art of bleaching wax consists in increasing its surface; for which purpose it must be melted with a degree of heat not sufficient to alter its quality, in a caldron so disposed, that the melted wax may flow gradually through a pipe at the bottom of the caldron into a large tub filled with water, in which is fitted a large wooden cylinder, that turns continually round its axis, and upon which the melted wax falls. As the surface of this cylinder is always moistened with cold water, the wax falling upon it does not adhere to it, but quickly becomes solid and flat, and acquires the form of ribbands. The continual rotation of the cylinder carries off these ribbands as fast as they are formed, and distributes them through the tub. When all the wax that is to be whitened is thus formed, it is put upon large frames covered with linen cloth, which are supported about a foot and a half above the ground, in a situation exposed to the air, the dew, and the sun. The thickness of the several ribbands, thus placed upon the frames, ought not to exceed an inch and a half, and they ought to be moved from time to time, that they may all be equally exposed to the action of the air. If the weather be favourable, the colour will be changed in the space of some days. It is then to be re-melted and formed into ribbands, and exposed to the action of the air as before. These operations are to be repeated till the wax is rendered perfectly white, and then it is to be melted into cakes, or formed into candles.

* Wax is composed, according to MM. Gay-Lussac and Thenard, of

Oxygen,	5.544
Hydrogen,	12.672
Carbon,	81.784
	100.000

See Cerin.*

Wax is employed for many purposes in several arts. It is also used in medicine as a softening, emollient, and relaxing remedy: but it is only used externally, mixed with other substances.

Weld, or **Woald** (reseda luteola, Linn.), is a plant cultivated in Kent, Herefordshire, and many other parts of this kingdom. The whole of the plant is used for dyeing yellow; though some assert, that the seeds only afford the colouring matter.

Two sorts of weld are distinguished: the bastard, or wild, which grows naturally in the fields; and the cultivated, the stalks of which are smaller, and not so high. For dyeing, the latter is preferred, it abounding more in colouring matter. The more slender the stalk, the more it is valued.

When the weld is ripe, it is pulled, dried, and made into bundles, in which state it is used.

The yellow communicated to wool by weld has little permanency, if the wool be not previously prepared by some mordant. For this purpose alum and tartar are used, by means of which this plant gives a very pure yellow, which has the advantage of being permanent.

For the boiling, which is conducted in the common way, Hellot directs four ounces of alum to every pound of wool, and only one ounce of tartar: many dyers, however, use half as much tartar as alum. Tartar renders the colour paler, but more lively.

For the welding, that is, for the dyeing with weld, the plant is boiled in a fresh bath, enclosing it in a bag of thin linen, and keeping it from rising to the top by means of a heavy wooden cross. Some dyers boil it till it sinks to the bottom of the copper, and then let a cross down upon it: others, when it is boiled, take it out with a rake and throw it away.

Hellot directs five or six pounds of weld for every pound of cloth; but dyers seldom use so much, contenting themselves with three or four pounds, or even much less.

To dye silk plain yellow, in general no other ingredient than weld is used. The silk ought to be scoured in the proportion of twenty pounds of soap to the hundred, and afterward alumed and refreshed, that is, washed after the aluming.

A bath is prepared with two pounds of weld for each pound of silk, which after a quarter of an hour's boiling is to be passed through a sieve or cloth into a vat: when it is of such a temperature as the hand can bear, the silk is put in, and turned till the colour is become uniform: during this operation the weld is boiled a second time in fresh water; about half of the first bath is taken out, and its place supplied by a fresh decoction. This fresh bath may be used a little hotter than the former; too great a degree of heat, however, must be avoided, that no part of the colour already fixed may be dissolved; it is to be turned as before, and in the mean time a quantity of the ashes of wine-lees is to be dissolved in a part of the second decoction; the silk is to be taken out of the bath, that more or less of this solution may be put in, according to the shade required. After it has been turned a few times, a hank is wrung with the pin, that it may be seen whether the colour be sufficiently full, and have the proper gold cast: if it should not, a little more of the alkaline solution is added, the effect of which is to give the colour a gold cast, and to render it deeper. In this way the process is to be continued, until the silk has attained the desired shade; the alkaline solution may also be added along with the second decoction of the weld, always taking care, that the bath is not too hot.

If we wish to produce yellows with more of a gold or jonquille colour, a quantity of anotta proportioned to the shade required must be added to the bath along with the alkali.

A water-colour, called weld-yellow, is much used by paper hanging manufacturers. This is the colouring matter of weld precipitated with an earthy base. The following is given in the Philosophical Magazine as a method of preparing it very fine: —Into a copper vessel put four pounds of fine washed whiting and as much soft water, and boil them together, stirring them with a deal stick, till the whole forms a smooth mixture: then add gradually twelve ounces of powdered alum, still stirring, till the effervescence ceases, and the whole is well mixed. Into another copper put any quantity of weld, with the roots uppermost, pour in soft water enough to cover every part containing seed; let it boil, but not more than a quarter of an hour; take out the weld, and set it to drain, and pass the whole of the liquor through flannel. To the hot mixture of earth and water, add as much of this decoction as will produce a good colour, keep it on the fire till it boils, and then pour out into a deal or earthen vessel. The next day the liquor may be decanted, and the colour dried on chalk.

Welter's Tube. See Laboratory.

* Wernerite. *Foliated Scapolite*.*

* Wheat Flour. See Gluten and Zimome.*

Wheat. See Bread, Gluten, Starch.

* Whet-Slate. Colour greenish-gray. Massive. Feebly glimmering. Fracture slaty in the large; splintery in the small. Fragments tabular. Translucent on the edges. Streak grayish-white. Soft in a low degree. Feels rather greasy. Sp. gr. 2.722. It occurs in beds in primitive and transition clay-slate. It is found at Seifersdorf near Freyberg. Very fine varieties are brought from Turkey, called Honestones. It is used for sharpening steel instruments.*

Whey. The fluid part of milk which remains after the curd has been separated. See Milk. It contains a saccharine matter, some butter, and a small portion of cheese.

* Whiskey. Dilute *Alcohol*, which see, and Distillation.*

White Copper. See Tutenag.

White, Spanish, and **White Lead**. See **Ceruse**.

Whiting. Chalk cleared of its grosser impurities, then ground in a mill, and made up into small loaves, is sold under the name of whiting.

Wine. Chemists give the name of wine in general to all liquors that have become spirituous by fermentation. Thus cider, beer, hydromel or mead, and other similar liquors, are wines.

The principles and theory of the fermentation which produces these liquors are essentially the same. The more general principles we have explained under the article **Fermentation**.

All those nutritive, vegetable, and animal matters, which contain sugar ready formed, are susceptible of the spirituous fermentation. Thus wine may be made of all the juices of plants, the sap of trees, the infusions and decoctions of farinaceous vegetables, the milk of frugivorous animals; and lastly, it may be made of all ripe succulent fruits; but all these substances are not equally proper to be changed into a good and generous wine.

As the production of alcohol is the result of the spirituous fermentation, that wine may be considered as essentially the best, which contains most alcohol. But of all substances susceptible of the spirituous fermentation, none is capable of being converted into so good wine, as the juice of the grapes of France, or of other countries that are nearly in the same latitude, or in the same temperature. The grapes of hotter countries, and even those of the southern provinces of France, do indeed furnish wines, that have a more agreeable, that is more of a saccharine taste; but these wines, though they are sufficiently strong, are not so spirituous as those of the provinces near the middle of France: at least, from these latter wines the best vinegar and brandy are made. As an example, therefore, of spirituous fermentation in general, we shall describe the method of making wine from the juice of the grapes of France.

This juice, when newly expressed, and before it has begun to ferment, is called must, and in common language sweet wine. It is turbid, has an agreeable and very saccharine taste. It is very laxative; and when drank too freely, or by persons disposed to diarrhœas, it is apt to occasion these disorders. Its consistence is somewhat less fluid than that of water, and it becomes almost of a pitchy thickness when dried.

When the must is pressed from the grapes, and put into a proper vessel and place, with a temperature between fifty-five and sixty degrees, very sensible effects are produced in it, in a shorter or longer time according to the nature of the liquor, and the exposure of the place. It then swells, and is so rarefied, that it frequently overflows the vessel containing it, if this be nearly full. An intestine motion is excited among its parts, accompanied with a small hissing noise and evident ebullition. The bubbles rise to the surface, and at the same time is disengaged a quantity of carbonic acid of such purity, and so subtle and dangerous, that it is capable of killing instantly men and animals exposed to it in a place where the air is not renewed. The skins, stones, and other grosser matters of the grapes are buoyed up by the particles of disengaged air that adhere to their surface, are variously agitated, and are raised in form of a scum or soft and spongy crust, that covers the whole liquor. During the fermentation this crust is frequently raised, and broken by the air disengaged from the liquor which forces its way through it; afterward the crust subsides, and becomes entire as before.

These effects continue while the fermentation is brisk, and at last gradually cease: then the crust, being no longer supported, falls in pieces to the bottom of the liquor At this time, if we would have a strong and generous wine, all sensible fermentation must be stopped. This is done by putting the wine into close vessels, and carrying these into a cellar or other cool place.

After this first operation, an interval of repose takes place, as is indicated by the cessation of the sensible effects of the spirituous fermentation; and thus enables us to preserve a liquor no less agreeable in its taste, than useful for its reviving and nutritive qualities when drank moderately.

If we examine the wine produced by this first fermentation, we shall find, that it differs entirely and essentially from the juice of grapes before fermentation. Its sweet and saccharine taste is changed into one that is very different, though still agreeable, and somewhat spirituous and piquant. It has not the laxative quality of must, but affects the head, and occasions, as is well known, drunkenness. Lastly, if it be distilled, it yields, instead of the insipid water obtained from must by distillation with the heat of boiling water, a volatile, spirituous, and inflammable liquor called spirit of wine, or alcohol. This spirit is consequently a new being, produced by the kind of fermentation called the vinous or spirituous. See **Alcohol**.

When any liquor undergoes the spirituous fermentation, all its parts seem not to ferment at the same time; otherwise the fermentation would probably be very quickly completed, and the appearances would be much more striking: hence, in a liquor much disposed to fermentation, this motion is more quick and simultaneous than in another liquor less disposed. Experience has shown, that a wine, the fermentation of which is very slow and tedious, is never good or very spirituous; and therefore, when the weather is too cold, the fermentation is usually accelerated by heating the place in which the wine is made. A proposal has been made by a person very intelligent in economical affairs, to apply a greater than the usual heat to accelerate the fermentation of the wine, in those years in which grapes have not been sufficiently ripened, and when the juice is not sufficiently disposed to fermentation.

A too hasty and violent fermentation is perhaps also hurtful, from the dissipation and loss of some of the spirit; but of this we are not certain. However, we may distinguish in the ordinary method of making wines of grapes, two periods in the fermentation; the first of which lasts during the appearance of the sensible effects above mentioned, in which the greatest number of fermentable particles ferment. After this first effort of fermentation, these effects sensibly diminish, and ought to be stopped, for reasons hereafter to be mentioned. The fermentative motion of the liquors then ceases. The heterogeneous parts, that were suspended in the wines by this motion, and render it muddy, are separated, and form a sediment called the lees; after which the wine becomes clear; but though the operation is then considered as finished, and the fermentation apparently ceases, it does not really cease; and it ought to be continued in some degree, if we would have good wine.

In this new wine a part of the liquor probably remains, that has not fermented, and which afterward ferments, but so very slowly, that none of the sensible effects produced in the first fermentation are here perceived. The fermentation therefore still continues in the wine, during a longer or shorter time, although in an imperceptible manner; and this is the second period of the spirituous fermentation, which may be called the imperceptible fermentation. We may easily perceive, that the effect of this imperceptible fermentation is the gradual increase of the quantity of alcohol. It has also another effect no less advantageous, namely, the separation of the acid salt called tartar from the wine. This matter is therefore a second sediment, that is formed in the wine, and adheres to the sides of the containing vessels. As the taste of tartar is harsh and disagreeable, it is evident, that the wine, which by means of the insensible fermentation has acquired more alcohol, and has disengaged itself of the greater part of its tartar, ought to be much better and more agreeable; and for this reason chiefly old wine is universally preferable to new wine.

But insensible fermentation can only ripen and meliorate the wine, if the sensible fermentation have regularly proceeded, and been stopped in due time. We know certainly, that if a sufficient time have not been allowed for the first period of the fermentation, the unfermented matter that remains, being in too large a quantity, will then ferment in the bottles, or close vessels in which the wine is put, and will occasion effects so much more sensible, as the first fermentation shall have been sooner interrupted: hence these wines are always turbid, emit bubbles, and sometimes break the bottles, from the large quantity of air disengaged during the fermentation.

We have an instance of these effects in the wine of Champagne, and in others of the same kind. The sensible fermentation of these wines is interrupted, or rather suppressed, that they may have this sparkling quality. It is well known, that these wines make the corks fly out of the bottles; that they sparkle and froth when they are poured into glasses; and lastly, that they have a taste much more lively and more piquant than wines that do not sparkle: but this sparkling quality, and all the effects depending on it, are only caused by a considerable quantity of carbonic acid gas, which is disengaged during the confined fermentation, that the wine has undergone in close vessels. This air not having an opportunity of escaping, and of being dissipated as fast as it is disengaged, and being interposed betwixt all the parts of the wine, combines in some measure with them, and adheres in the same manner as it does to certain mineral waters, in which it produces nearly the same effects. When this air is entirely disengaged from these wines, they no longer sparkle, they lose their piquancy of taste, become mild, and even almost insipid.

Such are the qualities that wine acquires in time, when its first fermentation has not continued sufficiently long. These qualities are given purposely to certain kinds of wine, to indulge taste or caprice; but such wines are supposed to be unfit for daily use. Wines for daily use ought to have undergone so completely the sensible fermentation, that the succeeding fermentation shall be insensible, or at least exceedingly little perceived. Wine, in which the first fermentation has been too far advanced, is liable to worse inconveniences than that in which the first fermentation has been too quickly suppressed; for every fermentable liquor is from its nature in a continual intestine motion, more or less strong according to circumstances, from the first instant of the spirituous fermentation till it is completely purified: hence from the time of the completion of the spirituous fermentation, or even before, the wine begins to undergo the acid or acetous fermentation. This acid fermentation is very slow and insensible, when the wine is included in very close vessels, and in a cool place; but it gradually advances, so that in a certain time the wine, instead of being improved, becomes at last sour. This evil cannot be remedied; because the fermentation may advance, but cannot be reverted.

Wine-merchants, therefore, when their wines become sour, can only conceal or absorb this acidity by certain substances, as by alkalis and absorbent earths. But these substances give to wine a dark greenish colour, and a taste which, though not acid, is somewhat disagreeable. Besides, calcareous earths accelerate considerably the total destruction and putrefaction of the wine. Oxides of lead, having the property of forming with the acid of vinegar a salt of an agreeable saccharine taste, which does not alter the colour of the wine, and which besides has the advantage of stopping fermentation and putrefaction, might be very well employed to remedy the acidity of wine, if lead and all its preparations were not pernicious to health, as they occasion most terrible colics, and even death, when taken internally. We cannot believe that any wine-merchant, knowing the evil consequences of lead, should, for the sake of gain, employ it for the purpose mentioned; but if there be any such persons, they must be considered as the poisoners and murderers of the public. At Alicant, where very sweet wines are made, it is the practice to mix a little lime with the grapes before they are pressed. This, however, can only neutralize the acid already existing in the grape.

If wine contain litharge, or any other oxide of lead, it may be discovered by evaporating some pints of it to dryness, and melting the residuum in a crucible, at the bottom of which a small button of lead may be found after the fusion: but an easier and more expeditious proof is by pouring into the wine some liquid sulphuret. If the precipitate occasioned by this addition of the sulphuret be white, or only coloured by the wine, we may know, that no lead is contained in it: but if the precipitate be dark coloured, brown, or blackish, we may conclude, that it contains lead or iron.

The only substances that cannot absorb or destroy, but cover and render supportable the sharpness of wine, without any inconvenience, are sugar, honey, and other saccharine alimentary matters; but they can succeed only when the wine is very little acid, and when an exceeding small quantity only of these substances is sufficient to produce the desired effect; otherwise the wine would have a sweetish, tart, and not agreeable taste.

From what is here said concerning the acescency of wine, we may conclude, that when this accident happens, it cannot by any good method be remedied, and that nothing remains to be done with sour wine but to sell it to vinegar-makers, as all honest wine-merchants do.

* As the *must* of the grape contains a notable proportion of tartar, which our currant and gooseberry juices do not, I have been accustomed, for many years, to recommend in my lectures, the addition of a small portion of that salt to our *must*, to make it ferment into a more genuine wine. Dr. M'Culloch has lately prescribed the same addition in his popular treatise on the art of making wine.

The following is Mr. Brande's valuable table of the quantity of spirit in different kinds of wine:—

		Proportion of spirit per cent by measure.
1.	Lissa,	26.47
	Ditto,	24.35
	Average,	25.41
2.	Raisin wine,	26.40
	Ditto,	25.77
	Ditto,	23.20
	Average,	25.12
3.	Marsala,	26.3
	Ditto,	25.5
	Average,	25.9
4.	Madeira,	24.42
	Ditto,	23.93
	Ditto (Sircial)	21.40
	Ditto,	19.24
	Average,	22.27
5.	Currant wine,	20.55
6.	Sherry,	19.81
	Ditto,	19.83
	Ditto,	18.79
	Ditto,	18.25
	Average,	19.17
7.	Teneriffe,	19.79
8.	Colares,	19.75
9.	Lachryma Christi,	19.70
10.	Constantia, white,	19.75
11.	Ditto red,	18.92
12.	Lisbon,	18.94
13.	Malaga, (1666)	18.94
14.	Bucellas,	18.49
15.	Red Madeira,	22.30
	Ditto,	18.40
	Average,	20.35
16.	Cape Muschat,	18.25
17.	Cape Madeira,	22.94
	Ditto,	20.50
	Ditto,	18.11
	Average,	20.51
18.	Grape wine,	18.11
19.	Calcavella,	19.20
	Ditto,	18.10
	Average,	18.65
20.	Vidonia,	19.25
21.	Alba Flora,	17.26
22.	Malaga,	17.26

		Proportion of spirit per cent by measure.
23.	White Hermitage,	17.43
24.	Rousillon,	19.00
	Ditto	17.26
	Average,	18.13
25.	Claret,	17.11
	Ditto	16.32
	Ditto	14.08
	Ditto	12.91
	Average,	15.10
26.	Malmsey Madeira,	16.40
27.	Lunel,	15.52
28.	Sheraaz,	15.52
29.	Syracuse,	15.28
30.	Sauterne,	14.22
31.	Burgundy,	16.60
	Ditto	15.22
	Ditto	14.53
	Ditto	11.95
	Average,	14.57
32.	Hock,	14.37
	Ditto	13.00
	Ditto (old in cask)	8.88
	Average,	12.08
33.	Nice,	14.63
34.	Barsac,	13.86
35.	Tent,	13.30
36.	Champagne, (still)	13.80
	Ditto (sparkling)	12.80
	Ditto (red)	12.56
	Ditto (ditto)	11.30
	Average,	12.61
37.	Red Hermitage,	12.32
38.	Vin de Grave,	13.94
	Ditto	12.80
	Average,	13.37
39.	Frontignac,	12.79
40.	Cote Rotie,	12.32
41.	Gooseberry wine,	11.84
42.	Orange wine,—average of six samples made by a London manufacturer,	11.26
43.	Tokay,	9.88
44.	Elder wine,	9.87
45.	Cyder, highest average,	9.87
	Ditto, lowest ditto	5.21
46.	Perry, average of four samples,	7.26
47.	Mead,	7.32
48.	Ale (Burton)	8.88
	Ditto (Edinburgh)	6.20
	Ditto (Dorchester)	5.56
	Average,	6.87
49.	Brown stout,	6.80
50.	London Porter (average)	4.20
51.	Ditto small beer, (ditto)	1.28
52.	Brandy,	53.39
53.	Rum,	53.68
54.	Gin,	51.60
55.	Scotch Whiskey,	54.32
56.	Irish ditto	53.90

* WITHERITE. Carbonate of barytes. See HEAVY-SPAR.*

WOAD, Isatis, Glastum, is a plant which grows wild in some parts of France, and on the coasts of the Baltic Sea; the wild woad, and that which is cultivated for the use of the dyers, appear to be the same species of plant.

The preparation of woad for dyeing, as practised in France, is minutely described by Astruc, in his Memoirs for a Natural History of Languedoc.—The plant puts forth at first five or six upright leaves about a foot long and six inches broad; when these hang downwards, and turn yellow, they are fit for gathering; five crops are gathered in one year. The leaves are carried directly to a mill, much resembling the oil or tan-mills, and ground into a smooth paste. If this process were deferred for some time, they would putrefy, and send forth an insupportable stench. The paste is laid in heaps pressed close and smooth, and the blackish crust, which forms on the outside, reunited if it happen to crack: if this were neglected, little worms would be produced in the cracks, and the woad would lose part of its strength. After lying for fifteen days, the heaps are opened, the crust rubbed and mixed with the inside, and the matter formed into oval balls, which are pressed close and solid in wooden moulds. These are dried upon hurdles: in the sun they turn black on the outside, in a close place yellowish, especially if the weather be rainy. The dealers in this commodity prefer the first, though it is said the workmen find no considerable difference between the two. The good balls are distinguished by their being weighty, of a pretty agreeable smell, and, when rubbed, of a violet colour within.

For the use of the dyer, these balls require a farther preparation; they are beaten with wooden mallets, on a brick or stone floor, into a gross powder, which is heaped up in the middle of the room to the height of four feet, a space being left for passing round the sides. The powder moistened with water ferments, grows hot, and throws out a thick fetid fume. It is shovelled backward and forward, and moistened every day for twelve days; after which it is stirred less frequently, without watering; and at length made into a heap for the dyer.

The powder thus prepared gives only brownish tinctures of different shades to water, to alcohol, to ammonia, and to fixed alkaline lixivia; rubbed on paper, it communicates a green stain. On diluting the powder with boiling water, and, after standing for some hours in a close vessel, adding about one-twentieth its weight of lime newly slaked, digesting in a gentle warmth, and stirring the whole together every three or four hours, a new fermentation begins; a blue froth rises to the surface, and the liquor, though it appears itself of a reddish colour, dyes woollen of a green; which, like the green from indigo, changes in the air to a blue. This is one of the nicest processes in the art of dyeing, and does not well succeed in the way of a small experiment.

* **Wodanium.** A new metal recently discovered by Lampadius in the mineral called *Woodan pyrites.* This metal has a bronze-yellow colour similar to that of cobalt glance; and its sp. gr. is 11.470. It is malleable; its fracture is hackly; it has the hardness of fluor spar; and is strongly attracted by the magnet.

It is not tarnished by exposure to the atmosphere at the common temperature; but when heated it is converted into a black oxide.

The solution of this metal in acids is colourless; or at least has only a slight wine-yellow tinge. Its hydrated carbonate is also white. The hydrate, precipitated by caustic ammonia, is indigo-blue.

Neither the alkaline phosphates nor arseniates occasion any precipitate, when dropped into a saturated solution of this metal in an acid; nor is any precipitate produced by the infusion of galls. A plate of zinc throws down a black metallic powder from the solution of this metal in muriatic acid. Prussiate of potash throws down a pearl-gray precipitate.

Nitric acid dissolves with facility both the metal and its oxide, and the solution yields colourless needle-form crystals, which readily dissolve in water.—*Gilbert's Annalen der Physik, September* 1818.*

* **Woodan Pyrites.** See Ores of Wodanium.*

* **Wood (Opal).** See Opal.*

Wood (Rock). The ligniform asbestus.

* **Wood-stone.** A sub-species of hornstone.*

* **Wood-tin.** See Ores of Tin.*

Wootz. The metal extracted from some kind of iron ore in the East Indies, apparently of good quality. It contains more carbon than steel, and less than cast iron, but from want of skill in the management is far from homogeneous.—*Phil. Trans.*

* **Wort.** See Beer, Distillation, and Fermentation.*

* **Wolfram.** See Ores of Tungsten.*

Y

* **YANOLITE.** Axinite.*

* **Yeast.** See Fermentation, and Bread.*

* **Yellow Earth.** Colour ochre-yellow. Massive. Dull. Fracture slaty or earthy. Streak somewhat shining. Opaque. Soils slightly. Soft. Easily frangible. Adheres to the tongue. Feels rather greasy. Sp. grav. 2.24. Before the blow-pipe it is converted into a black and shining enamel. Its constituents are, silica 92, alumina 2, lime 3, iron 3.—*Merat-Guillot.* It is found at Wehraw in Upper Lusatia, where it is associated with clay and clay-ironstone. When burnt, it is sold by the Dutch as a pigment, under the name of English red. It was used as a yellow paint by the ancients.*

* **Yenite.** Lievrite.*

Yttria. This is a new earth, discovered in 1794 by Prof. Gadolin in a stone from Ytterby in Sweden. See Gadolinite.

It may be obtained most readily by fusing the gadolinite with two parts of caustic potash, washing the mass with boiling water, and filtering the liquor, which is of a fine green. This liquor is to be evaporated, till no more oxide of manganese falls down from it in a black powder; after which the liquid is to be saturated with nitric acid. At the same time digest the sediment, that was not dissolved, in very dilute nitric acid, which will dissolve the earth with much heat, leaving the silex, and the highly oxided iron, undissolved. Mix the two liquors, evaporate them to dryness, redissolve, and filter, which will separate any silex or oxide of iron that may have been left. A few drops of a solution of carbonate of potash will separate any lime that may be present, and a cautious addition of hydrosulphuret of potash will throw down the oxide of manganese that may have been left; but if too much be employed, it will throw down the yttria likewise. Lastly, the yttria is to be precipitated by pure ammonia, well washed, and dried.

Yttria is perfectly white, when not contaminated with oxide of manganese, from which it is not easily freed. Its specific gravity is 4.842. It has neither taste nor smell. It is infusible alone; but with borax melts into a transparent glass, or opaque white, if the borax were in excess. It is insoluble in water, and in caustic fixed alkalis; but it dissolves in carbonate of ammonia, though it requires five or six times as much as glucine. It is soluble in most of the acids. The oxalic acid, or oxalate of ammonia, forms precipitates in its solutions perfectly resembling the muriate of silver. Prussiate of potash, crystallized and redissolved in water, throws it down in white grains; phosphate of soda, in white gelatinous flakes; infusion of galls, in brown flocks.

Some chemists are inclined to consider yttria rather as a metallic than as an earthy substance, their reasons are its specific gravity, its forming coloured salts, and its property of oxygenizing muriatic acid after it has undergone a long calcination.—*Crell's Chem. Ann.—Scherer's Journ.—Annales de Chimie.*

* When yttria is treated with potassium in the same manner as the other earths, similar results are obtained; the potassium becomes potash, and the earth gains appearances of metallization, so that it is scarcely to be doubted, says Sir H. Davy, that yttria consists of inflammable matter, metallic in its nature, combined with oxygen. According to Klaproth, 55 parts of yttria combine with 18 parts of carbonic acid; consequently, if it be supposed that the carbonate of yttria consists of one prime proportion of earth and one of acid, its prime equivalent will be 8.403; and that of its metallic basis probably 7.4. The salts of yttria have the following general characters.—

1. Many of them are insoluble in water.

2. Precipitates are occasioned in those which dissolve, by phosphate of soda, carbonate of soda, oxalate of ammonia, tartrate of potash, and ferroprussiate of potash.

3. If we except the sweet-tasted soluble sulphate of yttria, the other salts of this earth resemble those with base of lime in their solubility.*

* Yttro-Tantalite. An ore of Tantalum.*

* Yttro-Cerite. Colours reddish and grayish-white, and violet-blue. Massive, and in crusts. Cleavage indistinct. Opaque. Yields to the knife. Scratches fluor. Sp. gr. 3.447. Its constituents are, oxide of cerium 13.15, yttria 14.6, lime 47.77, fluoric acid 24.45.—*Berzelius.* It has hitherto been found only at Finbo, near Fahlun in Sweden, imbedded in quartz, or incrusting pyrophysalite.*

Z

ZAFFRE, *or* SAFFRE, is the residuum of cobalt, after the sulphur, arsenic, and other volatile matters of this mineral have been expelled by calcination.

The zaffre that is commonly sold, and which comes from Saxony, is a mixture of oxide of cobalt with some vitrifiable earth. It is of a gray colour, as all the oxides of cobalt are before vitrification.

* Zeolite. The name of a very extensive mineral *genus*, containing the following species:—1. Dodecahedral zeolite or leucite; 2. hexahedral zeolite or analcime; 3. rhomboidal zeolite, chabasite, or chabasie; 4. pyramidal zeolite, or cross stone; 5. di-prismatic zeolite, or laumonite; 6. prismatic zeolite, or mesotype, divided into three sub-species,—fibrous zeolite, natrolite, and mealy zeolite; 7. prismatoidal zeolite, or stilbite, comprehending foliated zeolite, and radiated zeolite; 8. axifrangible zeolite, or apophyllite. The following belong to this place:

6. *Prismatic zeolite* or *mesotype.*

§ 1. *Fibrous zeolite*, of which there are two kinds; the acicular or needle zeolite, and common fibrous zeolite.

a. Acicular or *needle zeolite*, the mesotype of Haüy. Colours grayish, yellowish or reddish-white. Massive, in distinct concretions, and crystallized Primitive form, a prism of 91° 25′. The following are secondary figures:—An acicular rectangular four-sided prism, very flatly acuminated with four planes, set on the lateral planes; sometimes two of the acuminating planes disappear, when there is formed an acute bevelment, or the prism is sometimes truncated on the edges. Lateral planes, longitudinally streaked. Shining, inclining to pearly. Cleavage twofold. Fracture small grained uneven. Fragments splintery. Translucent. Refracts double. As hard as apatite. Brittle. Sp. gr. 2.0 to 2.3. It intumesces before the blow-pipe, and forms a jelly with acids. It becomes elastic by heating, and retains this property some time after it has cooled. The free extremity of the crystal with the acumination, shows positive, the attached end, negative electricity. Its constituents are, silica 50.24, alumina 29.3, lime 9.46, water 10.—*Vauquelin.* It occurs in secondary trap rocks, as in basalt, green-stone, and amygdaloid. It is found near the village of Old Kilpatrick, Dumbartonshire; in Ayrshire and Perthshire, always in trap rocks; in Iceland and the Faroe Islands.

b. Common fibrous zeolite. Colour white. Massive, in distinct concretions, and in capillary crystals. Glimmering, pearly. Fragments splintery. Faintly translucent. Hardness as before. Rather brittle. Sp. gr. 2.16 to 2.2. Chemical characters and situations as above. Its constituents are, silica 49, alumina 27, soda 17, water 9.5.—*Smithson.*

§ 2. *Mealy zeolite.* Colour white, of various shades. Massive, imitative, in a crust or in delicate fibrous concretions. Feebly glimmering. Fracture coarse earthy. Opaque. The mass is soft, but the minute parts as hard as the preceding. Sectile. Most easily frangible. Does not adhere to the tongue. Feels meagre. Sometimes so light as nearly to float on water. It intumesces, and gelatinizes as the preceding. Its constituents are, silica 60, alumina 15.6, lime 8, oxide of iron 1.8, loss, by exposure to heat, 11.6.—*Hisinger*. It occurs like the others. It is found near Tantallon-castle, in East Lothian, and in the islands of Skye, Mull, and Canna.

7. *Prismatoidal zeolite*, or *stilbite*. Of this there are two sub-species; the foliated and radiated.

§ 1. *Foliated zeolite*, the stilbite of Haüy. Colour white, of various shades. Massive, disseminated, imitative, in distinct granular concretions, and crystallized. Primitive form, a prism of 99° 22′. Secondary forms are, a low oblique four-sided prism, variously truncated; a low equiangular six-sided prism; and an eight-sided prism, from truncation of all the edges of the four-sided prism. Lateral planes transversely streaked. Shining, pearly. Cleavage single. Fracture conchoidal. Translucent. Refracts single. As hard as calcareous spar. Brittle. Sp. gr. 2. to 2.2. It intumesces and phosphoresces before the blow-pipe, but does not form a jelly with acids. Its constituents are, silica 52.6, alumina 17.5, lime 9, water 18.5.—*Vauquelin*. It occurs principally in secondary amygdaloid, either in drusy cavities, or in contemporaneous veins. It is also met with in primitive and transition mountains. Very beautiful specimens of the red foliated and radiated zeolites are found at Carbeth in Stirlingshire, and at Loch Humphrey in Dumbartonshire; also in the secondary trap rocks of the Hebrides, as of Skye, Canna, and Mull; and in the north of Ireland.

§ 2. *Radiated zeolite*. Stilbite of Haüy. Colours yellowish-white and grayish-white. Massive, in angular pieces, in prismatic and granular concretions, and crystallized in a rectangular four-sided prism, variously modified by acuminations. Shining, pearly. Translucent. Hardness and chemical characters as above. Brittle. Sp. gr. 2.14. Its constituents are, silica 40.98, alumina 39.09, lime 10.95, water 16.5.—*Meyer*. Its situations are as the preceding.—*Jameson*.*

* Zero. The commencement of a scale marked 0. Thus we say the zero of Fahrenheit, which is 32° below the melting point of ice; the zero of the centigrade scale, which coincides with the freezing of water. The absolute zero is the imaginary point in the scale of temperature, when the whole heat is exhausted; the term of absolute cold, or privation of caloric. See Caloric.*

* Zimome. The gluten of wheat, treated by alcohol, is reduced to the third part of its bulk. This diminution is owing not merely to the loss of gliadine, but likewise to that of water. The residue is zimome, which may be obtained pure by boiling it repeatedly in alcohol, or by digesting it in repeated portions of that liquid cold, till it no longer gives out any gliadine. See Gliadine.

Zimome thus purified has the form of small globules, or constitutes a shapeless mass, which is hard, tough, destitute of cohesion, and of an ash-white colour. When washed in water, it recovers part of its viscosity, and becomes quickly brown, when left in contact of the air. It is specifically heavier than water. Its mode of fermenting is no longer that of gluten; for when it putrefies, it exhales a fetid urinous odour. It dissolves completely in vinegar, and in the mineral acids at a boiling temperature. With caustic potash, it combines and forms a kind of soap. When put into lime-water, or into the solutions of the alkaline carbonates, it becomes harder, and assumes a new appearance without dissolving. When thrown upon red-hot coals, it exhales an odour similar to that of burning hair or hoofs, and burns with flame.

Zimome is to be found in several parts of vegetables. It produces various kinds of fermentation, according to the nature of the substance with which it comes in contact.*

Zinc is a metal of a bluish-white colour, somewhat brighter than lead; of considerable hardness, and so malleable as not to be broken with the hammer, though it cannot be much extended in this way. It is very easily extended by the rollers of the flatting mill. Its sp. gr. is from 6.9 to 7.2. In a temperature between 210° and 300° of F., it has so much ductility that it can be drawn into wire, as well as laminated; for which a patent has been obtained by Messrs. Hobson and Sylvester of Sheffield. The zinc thus annealed and wrought retains the malleability it had acquired.

When broken by bending, its texture appears as if composed of cubical grains. On account of its imperfect malleability, it is difficult to reduce it into small parts by filing or hammering; but it may be granulated, like the malleable metals, by pouring it, when fused, into cold water; or, if it be heated nearly to melting, it is then sufficiently brittle to be pulverized.

It melts long before ignition, at about the 700th degree of Fahrenheit's thermometer; and, soon after it becomes red-hot, it burns with a dazzling white flame, of a bluish or yellowish tinge, and is oxidized with such rapidity, that it flies up in the form of white flowers, called the *flowers of zinc*, or *philosophical wool*. These are generated so plentifully, that the access of air is soon intercepted; and the combustion ceases, unless the matter be stirred, and a considerable heat kept up. The white oxide of zinc is not volatile, but is driven up merely by the force of the combustion. When it is again urged by a strong heat, it becomes converted into a clear yellow glass. If zinc be heated in closed vessels, it rises without decomposition.

* The oxide of zinc, according to the experiments of MM. Gay-Lussac and Berzelius, consists of 100 metal + 24.4 oxygen; whence the prime equivalent appears to be 4.1. Sir H. Davy makes it 4.4 from his own and his brother's experiments.

When zinc is burned in chlorine, a solid substance is formed of a whitish-gray colour; and semi-transparent. This is the only chloride of zinc, as there is only one oxide of the metal. It may likewise be made by heating together zinc filings and corrosive sublimate. It is as soft as wax, fuses at a temperature a little above 212°, and rises in the gaseous form at a heat much below ignition. Its taste is intensely acrid, and it corrodes the skin. It acts upon water, and dissolves in it, producing much heat; and its solution, decomposed by an alkali, affords the white hydrated oxide of zinc. This chloride has been called *butter of zinc*, and *muriate of zinc*. From the experiments of Dr. John Davy, it consists of nearly equal weights of zinc and chlorine. The equivalent proportions appear to be,—

Zinc4.1 + chlorine 4.5
Or Zinc 4.4 + 4.5.

Blende is the native sulphuret of zinc. The two bodies are difficult to combine artificially. The salts of zinc possess the following general characters:—

1. They generally yield colourless solutions with water.

2. Ferroprussiate of potash, hydrosulphuret of potash, hydriodate of potash, sulphuretted hydrogen, and alkalis, occasion white precipitates.

3. Infusion of galls produces no precipitate.*

The diluted sulphuric acid dissolves zinc; at the same time that the temperature of the solvent is increased, and much hydrogen escapes; an undissolved residue is left, which has been supposed to consist of plumbago. Proust, however, says, that it is a mixture of arsenic, lead, and copper. As the combination of the sulphuric acid and the oxide proceeds, the temperature diminishes, and the sulphate of zinc, which is more soluble in hot than cold water, begins to separate, and disturb the transparency of the fluid. If more water be added, the salt may be obtained in fine prismatic four-sided crystals. The white vitriol, or copperas, usually sold, is crystallized hastily, in the same manner as loaf-sugar, which on this account it resembles in appearance; it is slightly efflorescent. The white oxide of zinc is soluble in the sulphuric acid, and forms the same salt as is afforded by zinc itself.

The hydrogen gas, that is extricated from water by the action of sulphuric acid, carries up with it a portion of zinc, which is apparently dissolved in it; but this is deposited spontaneously, at least in part, if not wholly, by standing. It burns with a brighter flame than common hydrogen.

Sulphate of zinc is prepared in the large way from some varieties of the native sulphuret. The ore is roasted, wetted with water, and exposed to the air. The sulphur attracts oxygen, and is converted into sulphuric acid; and the metal, being at the same time oxidized, combines with the acid. After some time, the sulphate is extracted by solution in water; and the solution being evaporated to dryness, the mass is run into moulds. Thus the white vitriol of the shops, generally contains a small portion of iron, and sometimes of lead.

Sulphurous acid dissolves zinc, and sulphuretted hydrogen is evolved. The solution, by exposure to the air, deposites needly crystals, which, according to Fourcroy and Vauquelin, are sulphuretted sulphite of zinc. By dissolving oxide of zinc in sulphurous acid, the pure sulphite is obtained. This is soluble and crystallizable.

Diluted nitric acid combines rapidly with zinc, and produces much heat, at the same time that a large quantity of nitrous air flies off. The solution is very caustic, and affords crystals by evaporation and cooling, which slightly detonate upon hot coals, and leave oxide of zinc behind. This salt is deliquescent.

Muriatic acid acts very strongly upon zinc, and disengages much hydrogen; the solution, when evaporated, does not afford crystals, but becomes gelatinous. By a strong heat it is partly decomposed, a portion of the acid being expelled, and part of the muriate sublimes and condenses in a congeries of prisms.

Phosphoric acid dissolves zinc. The phosphate does not crystallize, but becomes gelatinous, and may be fused by a strong heat. The concrete phosphoric acid heated with zinc filings is decomposed.

Fluoric acid likewise dissolves zinc.

The boracic acid digested with zinc becomes milky; and if a solution of borax be added to a solution of muriate or nitrate of zinc, an insoluble borate of zinc is thrown down.

A solution of carbonic acid in water dissolves a small quantity of zinc, and more readily its oxide. If the solution be exposed to the air, a thin iridescent pellicle forms on its surface.

The acetic acid readily dissolves zinc, and yields by evaporation crystals of acetate of zinc, forming rhomboidal or hexagonal plates. These are not altered by exposure to the air, are soluble in water, and burn with a blue flame.

The succinic acid dissolves zinc with effervescence, and the solution yields long, slender, foliated crystals.

Zinc is readily dissolved in benzoic acid, and the solution yields needle-shaped crystals, which are soluble both in water and in alcohol. Heat decomposes them by volatilizing their acid.

The oxalic acid attacks zinc with a violent effervescence, and a white powder soon subsides, which is oxalate of zinc. If oxalic acid be dropped into a solution of sulphate, nitrate, or muriate of zinc, the same salt is precipitated; it being scarcely soluble in water unless an excess of acid be present. It contains seventy-five per cent of metal.

The tartaric acid likewise dissolves zinc with effervescence, and forms a salt difficult of solution in water.

The citric acid attacks zinc with effervescence, and small brilliant crystals of citrate of zinc are gradually deposited, which are insoluble in water. Their taste is styptic and metallic, and they are composed of equal parts of the acid and of oxide of zinc.

The malic acid dissolves zinc, and affords beautiful crystals by evaporation.

Lactic acid acts upon zinc with effervescence, and produces a crystallizable salt.

The metallic acids likewise combine with zinc. If arsenic acid be poured on it, an effervescence takes place, arsenical hydrogen gas is emitted, and a black powder falls down, which is arsenic in the metallic state, the zinc having deprived a portion of the arsenic, as well as the water, of its oxygen. If one part of zinc filings and two parts of dry arsenic acid be distilled in a retort, a violent detonation takes place when the retort becomes red, occasioned by the sudden absorption of the oxygen of the acid by the zinc. The arseniate of zinc may be precipitated by pouring arsenic acid into the solution of acetate of zinc, or by mixing a solution of an alkaline arseniate with that of sulphate of zinc. It is a white powder, insoluble in water.

By a similar process zinc may be combined with the molybdic acid, and with the oxide of tungsten, the tungstic acid of some, with both of which it forms a white insoluble compound; and with the chromic acid, the result of which compound is equally insoluble, but of an orange-red colour.

Zinc likewise forms some triple salts. Thus, if the white oxide of zinc be boiled in a solution of muriate of ammonia, a considerable portion is dissolved; and though part of the oxide is again deposited as the solution cools, some of it remains combined with the acid and alkali in the solution, and is not precipitable either by pure alkalis, or their carbonates. This triple salt does not crystallize.

If the acidulous tartrate of potash be boiled in water with zinc filings, a triple compound will be formed, which is very soluble in water, but not easily crystallized. This, like the preceding, cannot be precipitated from its solution either by pure or carbonated alkalis.

A triple sulphate of zinc and iron may be formed by mixing together the sulphates of iron and of zinc dissolved in water, or by dissolving iron and zinc in dilute sulphuric acid. This salt crystallizes in rhomboids, which nearly resemble the sulphate of zinc in figure, but are of a pale green colour. In taste, and in degree of solubility, it differs little from the sulphate of zinc. It contains a much larger proportion of zinc than of iron.

A triple sulphate of zinc and cobalt, as first noticed by Link, may be obtained by digesting zaffre in a solution of sulphate of zinc. On evaporation, large quadrilateral prisms are obtained, which effloresce on exposure to the air.

Zinc is precipitated from acids by the soluble earths and the alkalis: the latter redissolve the precipitate, if they be added in excess.

Zinc decomposes, or alters, the neutral sulphates in the dry way. When fused with sulphate of potash, it converts that salt into a sulphuret: the zinc at the same time being oxidized, and partly dissolved in the sulphuret. When pulverized zinc is added to fused nitre, or projected together with that salt into a red-hot crucible, a very violent detonation takes place; insomuch that it is necessary for the operator to be careful in using only small quantities, lest the burning matter should be thrown about. The zinc is oxidized, and part of the oxide combines with the alkali, with which it forms a compound soluble in water.

Zinc decomposes common salt, and also sal ammoniac, by combining with the muriatic acid. The filings of zinc likewise decompose alum, when boiled in a solution of that salt, probably by combining with its excess of acid.

Zinc may be combined with phosphorus, by projecting small pieces of phosphorus on the zinc melted in a crucible, the zinc being covered with a little resin, to prevent its oxidation. Phosphuret of zinc is white, with a shade of bluish-gray, has a metallic lustre, and is a little malleable.

When zinc and phosphorus are exposed to heat in a retort, a red sublimate rises, and likewise a bluish sublimate, in needly crystals, with a metallic lustre. If zinc and phosphoric acid be heated together, with or without a little charcoal, needly crystals are sublimed, of a silvery-white colour. All these, according to Pelletier, are phosphuretted oxides of zinc.

Most of the metallic combinations of zinc have been already treated of. It forms a brittle compound with antimony; and its effects on manganese, tungsten, and molybdena, have not yet been ascertained.

Zirconia was first discovered in the jargon of Ceylon by Klaproth, in 1789, and it has since been found in the jacinth. To obtain it, the stone should be calcined and thrown into cold water, to render it friable, and then powdered in an agate mortar. Mix the powder with nine parts of pure potash, and project the mixture by spoonfuls into a red-hot crucible, taking care that each portion is fused before another is added. Keep the whole in fusion, with an increased heat, for an hour and half. When cold, break the crucible, separate its contents, powder, and boil in water, to dissolve the alkali. Wash the insoluble part; dissolve in muriatic acid; heat the solution, that the silex may fall down; and precipitate the zircon by caustic fixed alkali. Or the zircon may be precipitated by carbonate of soda, and the carbonic acid expelled by heat.

* *New Process for preparing pure Zirconia.*

Powder the zircons very fine, mix them with two parts of pure potash, and heat them red-hot in a silver crucible, for an hour. Treat the substance obtained with distilled water, pour it on a filter, and wash the insoluble part well; it will be a compound of zirconia, silex, potash, and oxide of iron. Dissolve it in muriatic acid, and evaporate to dryness, to separate the silex. Redissolve the muriates of zirconia and iron in water; and to separate the zirconia which adheres to the silex, wash it with weak muriatic acid, and add this to he solution. Filter the fluid, and precipitate the zirconia and iron by pure ammonia; wash the precipitates well, and then treat the hydrates with oxalic acid, boiling them well together, that the acid may act on the iron, retaining it in solution, whilst an insoluble oxalate of zirconia is formed. It is then to be filtered, and the oxalate washed, until no iron can be detected in the water that passes. The earthy oxalate is, when dry, of an opaline colour. After being well washed, it is to be decomposed by heat in a platinum crucible.

Thus obtained, the zirconia is perfectly pure, but is not affected by acids. It must be reacted on by potash as before, and then washed until the alkali is removed. Afterwards dissolve it in muriatic acid, and precipitate by ammonia. The hydrate thrown down, when well washed, is perfectly pure, and easily soluble in acids.—*MM. Dubois and Silveira, Ann. de Chimie, et de Phys.* xiv. p. 110.*

Zirconia is a fine white powder, without taste or smell, but somewhat harsh to the touch. It is insoluble in water; yet if slowly dried, it coalesces into a semi-transparent yellowish mass, like gum-arabic, which retains one-third its weight of water. It unites with all the acids. It is insoluble in pure alkalis; but the alkaline carbonates dissolve it. Heated with the blow-pipe, it does not melt, but emits a yellowish phosphoric light. Heated in a crucible of charcoal, bedded in charcoal powder, placed in a stone crucible, and exposed to a good forge fire for some hours, it undergoes a pasty fusion, which unites its particles into a gray opaque mass, not truly vitreous, but more resembling porcelain. In this state it is sufficiently hard to strike fire with steel, and scratch glass; and is of the specific gravity of 4.3.

* There is the same evidence for believing that zirconia is a compound of a metal and oxygen, as that afforded by the action of potassium on the other earths. The alkaline metal, when brought into contact with zirconia ignited to whiteness, is, for the most part, converted into potash, and dark particles, which, when examined by a magnifying glass, appear metallic in some parts, of a chocolate-brown in others, are found diffused through the potash and the decompounded earth.

According to Sir H. Davy, 4.66 is the prime equivalent of zirconium on the oxygen scale, and 5.66 that of zirconia.*

***Zoisite.** A sub-species of prismatoidal augite, which is divided into two kinds, the common and friable.

§ 1. *Common zoisite.* Colour yellowish-gray. Massive, in granular and prismatic concretions, and crystallized in very oblique four-sided prisms, in which the obtuse lateral edges are often rounded, so that the crystals have a reed-like form. Shining, or glistening and resino-pearly. Cleavage, double. Fracture small grained uneven. Feebly translucent. As hard as epidote. Very easily frangible. Sp. gr. 3.3. It is affected by the blow-pipe, as epidote. Its constituents are, silica 43, alumina 29, lime 21, oxide of iron 3.—*Klaproth.* At the Saualp in Carinthia, it is found imbedded in a bed of quartz, along with cyanite, garnet, and augite; or it takes the place of feldspar in a granular rock, composed of quartz and mica. It is found in Glen Elg in Invernessshire, and in Shetland.

§ 2. *Friable zoisite.* Colour reddish-white, which is spotted with pale peach-blossom red. Massive, and in very fine loosely aggregated granular concretions. Feebly glimmering. Fracture intermediate between earthy and splintery. Translucent on the edges. Semi-hard. Brittle. Sp. gr. 3.3. Its constituents are, silica 44, alumina 32, lime 20, oxide of iron 2.5—*Klaproth*. It occurs imbedded in green talc, at Radelgraben in Carinthia.*

Zoöphytes. Scarcely any chemical experiments have been published on these interesting subjects, if we except the admirable dissertation by Mr. Hatchett, in the Philosophical Transactions for 1800. From this dissertation, and from a few experiments of Merat-Guillot, we learn, that the hard zoöphytes are composed chiefly of three ingredients: 1. An animal substance of the nature of coagulated albumen, varying in consistency; sometimes being gelatinous and almost liquid, at others of the consistency of cartilage. 2. Carbonate of lime. 3. Phosphate of lime.

In some zoöphytes, the animal matter is very scanty, and phosphate of lime wanting altogether; in others the animal matter is abundant, and the earthy salt pure carbonate of lime; while in others the animal matter is abundant, and the hardening salt a mixture of carbonate of lime and phosphate of lime; and there is a fourth class almost destitute of earthy salts altogether. Thus, there are four classes of zoöphytes; the first resemble porcellaneous shells; the second resemble mother-of-pearl shells; the third resemble crusts; and the fourth horn.

1. When the *madrepora virginea* is immersed in diluted nitric acid, it effervesces strongly, and is soon dissolved. A few gelatinous particles float in the solution, which is otherwise transparent and colourless. Ammonia precipitates nothing; but its carbonate throws down abundance of carbonate of lime. It is composed, then, of carbonate of lime and a little animal matter. The following zoöphytes yield nearly the same results:—

Madrepora muricata,
———— labyrinthica,
Millepora cerulea,
———— alcicornis,
Tubipora musica.

2. When the *madrepora ramea* is plunged into weak nitric acid, an effervescence is equally produced; but after all the soluble part is taken up, there remains a membrane which retains completely the original shape of the madrepore. The substance taken up is pure lime. Hence, this madrepore is composed of carbonate of lime, and a membranaceous substance, which, as in mother-of-pearl shells, retains the figure of the madrepore. The following zoöphytes yield nearly the same results:—

Madrepora fascicularis,
Millepora cellulosa,
———— fascialis,
———— truncata,
Iris hippuris.

The following substances, analyzed by Merat-Guillot, belong to this class from their composition, though it is difficult to say what are the species of zoöphytes which were analyzed. By *red coral*, he probably meant the *gorgonia nobilis*, though that substance is known, from Hatchett's analysis, to contain also some phosphate:—

	White coral.	*Red coral.*	*Articulated coralline.*
Carbonate of lime,	50	53.5	49
Animal matter,	50	46.5	51
	100	100.0	100‡

3. When the *madrepora polymorpha* is steeped in weak nitric acid, its shape continues unchanged; there remaining a tough membranaceous substance of a white colour and opaque, filled with a transparent jelly. The acid solution yields a slight precipitate of phosphate of lime, when treated with ammonia, and carbonate of ammonia throws down a copious precipitate of carbonate of lime. It is composed, therefore, of animal substance, partly in the state of jelly, partly in that of membrane, and hardened by carbonate of lime, together with a little phosphate of lime.

Flustra foliacea, treated in the same manner, left a finely reticulated membrane, which possessed the properties of coagulated albumen. The solution contained a little phosphate of lime, and yielded abundance of carbonate of lime when treated with the alkaline carbonates. The *corallina opuntia*, treated in the same manner, yielded the same constituents; with this difference, that no phosphate of lime could be detected in the fresh coralline, but the solution of burnt coralline yielded traces of it. The *iris ochracea* exhibits the same phenomena, and is formed of the same constituents. When dissolved in weak nitric acid, its colouring matter falls in the state of a fine red powder, neither soluble in nitric nor muriatic acid, nor changed by them; whereas the tinging matter of the *tubipora musica* is destroyed by these acids. The branches of this iris are divided by a series of knots. These knots are cartilaginous bodies connected together by a membraneous coat. Within this coat there is a conical cavity filled with the earthy or coralline matter; so that, in the recent state, the branches of the iris are capable of considerable motion, the knots answering the purpose of joints. See CORAL.

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‡ Merat-Guillot, *Ann. de Chim.* xxxiv. 71.

Mr. Hatchett analyzed many species of sponges, but found them all similar in their composition. The *spongia cancellata*, *oculata*, *infundibuliformis*, *palmata*, and *officinalis*, may be mentioned as specimens. They consist of gelatin, which they gradually give out to water, and a thin brittle membranous substance, which possesses the properties of coagulated albumen.

* ZUMATES. Combinations of the zumic acid with the salifiable bases.*

* ZUMIC ACID. See ACID (ZUMIC).*

ZUNDERERZ. Tinder ore. An ore of silver.

APPENDIX,

Containing several Tables referred to in the body of the Work. Many important Tables usually placed at the end of Chemical Treatises are inserted under the particular articles to which they belong. Thus the Tables of the Mineral Acids will be found under Acid (Muriatic), (Nitric), and (Sulphuric). For others, see Acid in general, Alcohol, Attraction, Caloric, Climate, Coal-gas, Combustion, Equivalents, Electricity, Gas, Hydrometer, Light, Metal, Rain, Salt, Water (Mineral), Wine, &c. &c.

I.—*Dr. Wollaston's Numerical Table of Chemical Equivalents.*

Dr. Wollaston's numbers represent the weights of the atoms of bodies, oxygen being called ten.

1. Hydrogen	1.32
2. Oxygen	10.00
3. Water	11.32
4. Carbon	7.54
5. Carbonic acid (20 oxygen)	27.54
6. Sulphur	20.00
7. Sulphuric acid (30 oxygen)	50.00
8. Phosphorus	17.40
9. Phosphoric acid (20 oxygen)	37.40
10. Azote or Nitrogen	17.54
11. Nitric acid (50 oxygen)	67.54
12. Muriatic acid, dry	34.10
13. Oxymuriatic acid (10 oxygen)	44.10
14. Chlorine 44.10 + 1.32 hydrogen = muriatic acid gas	45.42
15. Oxalic acid	47.0
16. Ammonia	21.5
17. Soda	39.1
18. Sodium (above — 10 oxygen)	29.1
19. Potash	59.1
20. Potassium (above — 10 oxygen)	49.1
21. Magnesia	24.6
22. Lime	35.46
23. Calcium (above — 10 oxygen)	25.46
24. Strontites	69.00
25. Barytes	97.00
26. Iron	34.50
Black oxide (10 oxygen)	44.50
Red oxide (15 oxygen)	49.50
27. Copper	40.00
Black oxide (10 oxygen)	50.00
28. Zinc	41.00
Oxide (10 oxygen)	51.00
29. Mercury	125.50
Red oxide (10 oxygen)	135.50
Black oxide (125.5 mercury)	261.00
30. Lead	129.50
Litharge (10 oxygen)	139.50
31. Silver	135.00
Oxide (10 oxygen)	145.00
32. Sub-carbonate of ammonia	49.00
Bi-carbonate (27.5 carbonic acid)	76.50
33. Sub-carbonate of soda	66.60
Bi-carbonate (27.5 C. A. + 11.3 water)	105.50
34. Sub-carbonate of potash	86.00
Bi-carbonate (27.5 C. A. + 11.3 water)	125.50
35. Carbonate of lime	63.00
36. ——— barytes	124.50
37. ——— lead	167.00
38. Sulphuric acid dry	50.00
39. Do. sp. gr. 1.850 (50 + 11.3 water)	61.30
40. Sulphate of soda (10 water = 113.2)	202.30
41. Sulphate of potash	109.10
42. Sulphate of magnesia dry	74.60
Do. crystallized (7 water = 79.3)	153.90
43. Sulphate of lime dry	85.50
Crystallized (2 water = 22.64)	108.10
44. Sulphate of strontites	119.00
45. ——— barytes	147.00
46. ——— copper (1 acid + 1 oxide + 5 water)	156.60
47. ——— iron (7 water)	173.80
48. ——— zinc (do.)	180.20
49. ——— lead	189.50
50. Nitric acid dry	67.54

Nitric acid, sp. gr. 1.50 (2 water = 22.64)	90.20
51. Nitrate of soda	106.60
52. ——— potash	126.60
53. ——— lime	103.00
54. ——— barytes	164.50
55. ——— lead	207.00
56. Muriate of ammonia	66.90
57. ——— soda	73.20
58. ——— potash	93.20
Oxymuriate of do. (60 oxygen)	153.20
59. Muriate of lime	169.60
60. ——— barytes	131.00
61. ——— lead	173.60
62. ——— silver	179.10
63. ——— mercury	170.10
64. Sub-muriate of do. (1 acid + 1 oxygen + 2 mercury)	296.10
65. Phosphate of lead	176.90
66. Oxalate of lead	186.50
67. Bin-oxalate of potash	153.00

* TABLES exhibiting a collective View of all the Frigorific Mixtures contained in Mr. Walker's Publication, 1808.

II.—*TABLE, consisting of Frigorific Mixtures, having the Power of generating, or creating Cold, without the aid of Ice, sufficient for all useful and Philosophical purposes, in any part of the World, at any Season.*

FRIGORIFIC MIXTURES WITHOUT ICE.

MIXTURES.		*Thermometer sinks,*	*Deg. of cold produced.*
Muriate of ammonia	5 parts	From + 50° to + 10°	40°
Nitrate of potash	5		
Water	16		
Muriate of ammonia	5 parts	From + 50° to + 4°	46
Nitrate of potash	5		
Sulphate of soda	8		
Water	16		
Nitrate of ammonia	1 part	From + 50° to + 4°	46
Water	1		
Nitrate of ammonia	1 part	From + 50° to — 7°	57
Carbonate of soda	1		
Water	1		
Sulphate of soda	3 parts	From + 50° to — 3°	53
Diluted nitric acid	2		
Sulphate of soda	6 parts	From + 50° to — 10°	60
Muriate of ammonia	4		
Nitrate of potash	2		
Diluted nitric acid	4		
Sulphate of soda	6 parts	From + 50° to — 14°	64
Nitrate of ammonia	5		
Diluted nitric acid	4		
Phosphate of soda	9 parts	From + 50° to — 12°	62
Diluted nitric acid	4		
Phosphate of soda	9 parts	From + 50° to — 21°	71
Nitrate of ammonia	6		
Diluted nitric acid	4		
Sulphate of soda	8 parts	From + 50° to 0°	50
Muriatic acid	5		
Sulphate of soda	5 parts	From + 50° to + 3°	47
Diluted sulphuric acid	4		

N. B.—If the materials are mixed at a warmer temperature, than that expressed in the Table, the effect will be proportionably greater; thus, if the most powerful of these mixtures be made, when the air is + 85°, it will sink the thermometer to + 2°.

III.—*TABLE consisting of Frigorific Mixtures, composed of Ice, with chemical Salts & Acids.*

Frigorific Mixtures with Ice.

MIXTURES.		*Thermometer sinks.*	*Deg. of cold produced.*
Snow, or pounded ice - - Muriate of soda - - -	2 parts 1	*From any temperature* to — 5°	*
Snow, or pounded ice - - Muriate of soda - - - Muriate of ammonia - -	5 parts 2 1	to — 12°	*
Snow, or pounded ice - - Muriate of soda - - - Muriate of ammonia - - Nitrate of potash - -	24 parts 10 5 5	to — 18°	*
Snow, or pounded ice - - Muriate of soda - - - Nitrate of ammonia - -	12 parts 5 5	to — 25°	*
Snow - - - - - - Diluted sulphuric acid - -	3 parts 2	From + 32° to — 23°	55
Snow - - - - - - Muriatic acid - - -	8 parts 5	From + 32° to — 27°	59
Snow - - - - - - Diluted nitric acid - -	7 parts 4	From + 32° to — 30°	62
Snow - - - - - - Muriate of lime - - -	4 parts 5	From + 32° to — 40°	72
Snow - - - - - - Cryst. muriate of lime - -	2 parts 3	From + 32° to — 50°	82
Snow - - - - - - Potash - - - - -	3 parts 4	From + 32° to — 51°	83

N. B.—The reason for the omissions in the last column of this Table, is, the thermometer sinking in these mixtures to the degree mentioned in the preceding column, and never lower, whatever may be the temperature of the materials at mixing.

IV.—*TABLE consisting of Frigorific Mixtures selected from the foregoing Tables, and combined so as to increase or extend Cold to the extremest Degrees.*

Combinations of Frigorific Mixtures.

MIXTURES.		*Thermometer sinks.*	*Deg. of cold produced.*
Phosphate of soda - - Nitrate of ammonia - - Diluted nitric acid - -	5 parts 3 4	From 0° to — 34°	34
Phosphate of soda - - Nitrate of ammonia - - Diluted mixed acids - -	3 parts 2 4	From — 34° to — 50°	16
Snow - - - - - - Diluted nitric acid - -	3 parts 2	From 0° to — 46°	46
Snow - - - - - - Diluted sulphuric acid - - Diluted nitric acid - -	8 parts 3 3	From — 10° to — 56°	46
Snow - - - - - - Diluted sulphuric acid - -	1 part 1	From — 20° to — 60°	40
Snow - - - - - - Muriate of lime - - -	3 parts 4	From + 20° to — 48°	68
Snow - - - - - - Muriate of lime - - -	3 parts 4	From + 10° to — 54°	64
Snow - - - - - - Muriate of lime - - -	2 parts 3	From — 15° to — 68°	53
Snow - - - - - - Cryst. muriate of lime - -	1 part 2	From 0° to — 66°	66
Snow - - - - - - Cryst. muriate of lime - -	1 part 3	From — 40° to — 73°	33
Snow - - - - - - Diluted sulphuric acid - -	8 parts 10	From — 68° to — 91°	23

N. B.—The materials in the first column are to be cooled, previously to mixing, to the temperature required, by mixtures taken from either of the preceding tables.*

V.—*TABLE of Capacities of different Substances for Caloric.*

In this Table, the authorities are marked by the initials of the respective authors' names. C. Crawford: K. Kirwan: Ir. Irvine: G. Gadolin: L. Lavoisier: W. Wilcke: M. Meyer.

GASES.

1. Hydrogen gas	21.4000	C.
2. Oxygen gas	4.7490	—
3. Atmospheric air	1.7900	—
4. Aqueous vapour	1.5500	C.
5. Carbonic acid gas	1.6454	—
6. Nitrogen gas	.7936	—

LIQUIDS.

7. Solution of carbonate of ammonia,	1.8510	K.
8. Solution of brown sugar	1.0860	—
9. Alcohol (15.44)	1.0860	—
10. Arterial blood	1.0300	C.
11. Water	1.0000	
12. Cow's milk	.9999	C.
13. Sulphuret of ammonia	.9940	K.
14. Solution of muriate of soda, 1 in 10 of water	.9360	G.
15. Alcohol (9.44)	.9300	Ir.
16. Sulphuric acid, diluted with 10 of water,	.9250	G.
17. Solution of muriate of soda, in 6.4 of water	.9050	G.
18. Venous blood	.8928	C.
19. Sulphuric acid, with 5 parts of water	.8760	G.
20. Solution of muriate of soda, in 5 of water	.8680	G.
21. Nitric acid (39)	.8440	K.
22. Solution of sulphate of magnesia, in 2 of water	.8440	—
23. Solution of muriate of soda in 8 of water	.8320	—
24. Solution of muriate of soda in 3.33 of water	.8200	G.
25. Solution of nitrate of potash in 8 of water	.8167	L.
26. Solution of muriate of soda in 2.8 of water	.8020	G.
27. Solution of muriate of ammonia in 1.5 of water	.7980	K.
28. Solution of muriate of soda saturated, or in 2.69 of water	.7930	G.
29. Solution of supertartrate of potash in 237.3 of water	.7650	K.
30. Solution of carbonate of potash	.7590	—
31. Colourless sulphuric acid (51.55,56,57)	.7580	—
32. Sulphuric acid, with 2 parts of water	.7490	G.
33. Solution of sulphate of iron in 2.5 of water	.7340	K
34. Solution of sulphate of soda in 2.9 of water	.7280	—
35. Olive oil	.7100	—
36. Water of ammonia, sp. gr. 0.997	.7080	K.
37. Muriatic acid, sp. gr. 1.122	.6800	—
38. Sulphuric acid, 4 parts with 5 of water	.6631	L.
39. Nitric acid, sp. gr. 1.29895	.6613	—
40. Solution of alum in 4.45 of water	.6490	M.
41. Mixture of nitric acid with lime, $9\frac{1}{3}$ to 1	.6189	L.
42. Sulphuric acid, with an equal weight of water	.6050	G.
43. Sulphuric acid, 4 parts with 3 of water	.6031	L.
44. Alcohol (9.15)	.6021	C.
45. Nitrous acid, sp. gr. 1.354	.5760	K.
46. Linseed oil	.5280	—
47. Spermaceti oil (53)	.5000	C.
48. Sulphuric acid, with $\frac{1}{2}$ of water	.5000	G.
49. Oil of turpentine (52)	.4720	K.
50. Sulphuric acid, with $\frac{1}{4}$ of water	.4420	G.
51. Sulphuric acid (31.55,56,57)	.4290	C.
52. Oil of turpentine (49)	.4000	Ir.
53. Spermaceti oil (47)	.3990	K.
54. Red wine vinegar	.3870	—
55. Sulphuric acid, concentrated and colourless (31)	.3390	G.
56. Sulphuric acid, sp. gr. 1.87058	.3345	L.
57. Sulphuric acid (31.51)	.3330	Ir.
58. Spermaceti melted	.3200	—
59. Quicksilver, sp. gr. 13.30	.0330	K.
60. Quicksilver	.0290	L.
61. ————	.0290	W.
62. ————	.0280	Ir.

SOLIDS.

63. Ice	.9000	K.
64. ——	.8000	Ir.
65. Ox hide with the hair	.7870	C.
66. Sheep's lungs	.7690	—
67. Beef of an ox	.7400	—
68. Scotch fir wood	.6500	M.
69. Lime tree wood	.2600	—
70. Spruce fir wood	.6000	—
71. Pitch pine wood	.5800	—
72. Apple tree wood	.5700	—

73.	Alder Wood	.5300	M.
74.	Sessile-leaved oak	.5100	—
75.	Ash wood	.5100	—
76.	Pear tree wood	.5000	—
77.	Rice	.5060	C.
78.	Horse-beans	.5020	—
79.	Dust of the pine tree	.5000	—
80.	Pease	.4920	—
81.	Beech	.4900	M.
82.	Hornbean wood	.4800	—
83.	Birch wood	.4800	—
84.	Wheat	.4770	C.
85.	Elm	.4700	M.
86.	White wax	.4500	G.
87.	Pedunculated oak wood	.4500	M.
88.	Prune tree	.4400	—
89.	Ebony wood	.4300	—
90.	Quicklime, with water, in the proportion of 16 to 9	.4391	L.
91.	Barley	.4210	C.
92.	Oats	.4160	—
93.	Charcoal of birch wood (99)	.3950	G.
94.	Carbonate of magnesia	.3790	—
95.	Prussian blue	.3300	—
96.	Quicklime saturated with water and dried	.2800	G.
97.	Pit coal	.2777	C.
98.	Artificial gypsum	.2640	G.
99.	Charcoal (93)	.2631	C.
100.	Chalk (108)	.2564	—
101.	Rust of iron	.2500	—
102.	White clay	.2410	G.
103.	White oxide of antimony washed	.2272	C.
104.	Oxide of copper	.2272	—
105.	Quicklime (107)	.2239	—
106.	Muriate of soda in crystals	.2260	G.
107.	Quicklime (105)	.2168	L.
108.	Chalk (100)	.2070	G.
109.	Crown glass	.2000	Ir.
110.	Agate, sp. gr. 2.648	.1950	W.
111.	Earthen ware	.1950	K.
112.	Crystal glass without lead	.1929	L.
113.	Cinders	.1923	C.
114.	Sulphur	.1890	Ir.
115.	Ashes of cinders	.1855	C.
116.	White glass, sp. gr. 2.386	.1870	W.
117.	White clay burnt	.1850	G.
118.	Black lead	.1830	—
119.	Sulphur	.1830	K.
120.	Oxide of antimony, nearly free of air	.1666	C.
121.	Rust of iron, ditto ditto	.1666	—
122.	Ashes of elm wood	.1402	—
123.	Iron (125.127, 128.132)	.1450	Ir.
124.	Oxide of zinc, nearly freed from air	.1369	C.
125.	White cast iron	.1320	G.
126.	White oxide of arsenic	.1260	—
127.	Iron (123.132)	.1269	C.
128.	Iron, sp. gr. 7876	.1260	W.
129.	Cast iron abounding in plumbago	.1240	G.
130.	Hardened steel	.1230	—
131.	Steel softened by fire	.1200	—
132.	Soft bar iron, sp. gr. 7.724	.1190	—
133.	Brass, sp. gr. 8.356 (135)	.1160	W.
134.	Copper, sp. gr. 8.785 (136)	.1140	W.
135.	Brass (133)	.1123	C.
136.	Copper (133)	.1111	—
137.	Sheet iron	.1099	L.
138.	Zinc, sp. gr. 7.154 (143)	.1020	W.
139.	White oxide of tin, nearly free of air	.990	C.
140.	Cast pure copper, heated between charcoal, and cooled slowly, sp. gr. 7.907	.990	G.
141.	Hammered copper, sp. gr. 9150	.970	G.
142.	Oxide of tin	.960	K.
143.	Zinc (198)	.943	C.
144.	Ashes of charcoal	.909	—
145.	Sublimated arsenic	.840	G.
146.	Silver, sp. gr. 10.001	.820	W.
147.	Tin (152)	.704	C.
148.	Yellow oxide of lead	.680	—
149.	White lead	.670	G.
150.	Antimony	.645	—
151.	Antimony, sp. gr. 6.107	.630	W.
152.	Tin, sp. gr. 7.380 (147)	.600	—
153.	Red oxide of lead	.590	G.
154.	Gold, sp. gr. 19.04	.500	W.
155.	Vitrified oxide of lead	.590	G.
156.	Bismuth, sp. gr. 9.861	.430	W.
157.	Lead, sp. gr. 11.45	.420	—
158.	———	.352	C.

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* The above capacities of the gases are all erroneous; and those of the other bodies are probably more or less incorrect. See CALORIC.*

TABLE VI.—*Correspondence of the Thermometers of Fahrenheit and Reaumur, and that of Celsius, or the Centigrade Thermometer of the modern French Chemists.*

Fahr.	Reaum.	Celsi.	Fahr.	Reaum.	Celsi.	Fahr.	Reaum.	Celsi.	Fahr.	Reaum.	Celsi.
212	80	100	148	51.5	64.4	85	23.5	29.4	22	4.4	5.5
211	79.5	99 4	147	51.1	63.8	84	23.1	28.8	21	4.8	6.1
210	79.1	98.8	146	50.6	63.3	83	22.6	28.3	20	5.3	6.6
209	78.6	98.3	145	50.2	62.7	82	22.2	27.7	19	5.7	7.2
208	78.2	97.7	144	49.7	62.2	81	21.7	27.2	18	6.2	7.7
207	77.7	97.2	143	49.3	61.6	80	21.3	26.6	17	6.6	8.3
206	77.3	96.6	142	48.8	61.1	79	20.8	26.1	16	7.1	8.8
205	76.8	96.1	141	48.4	60.5	78	20.4	25.5	15	7.5	9.4
204	76.4	95.5	140	48	60	77	20	25	14	8	10
203	76	95	139	47.5	59.4	76	19.5	24.4	13	8.4	10.5
202	75.5	94.4	138	41.1	58.8	75	18.1	23.8	12	8.8	11.1
201	75.1	93.8	137	46.6	58.3	74	18.6	23.3	11	9.3	11.6
200	74.6	93.3	136	46.2	57.7	73	18.2	22.7	10	9.7	12.2
199	74.2	92.7	135	45.7	57.2	72	17.7	22.2	9	10.2	12.7
198	73.7	92.2	134	45.3	56.6	71	17.3	21.6	8	10.6	13.3
197	73.3	91.6	133	44.8	56.1	70	16.8	21.1	7	11.1	13.8
196	72.8	91.1	132	44.4	55.5	69	16.4	20.5	6	11.5	14.4
195	72.4	90.5	131	44	55	68	16	20	5	12	15
194	72	90	130	43.5	54.4	67	15.5	19.4	4	12.4	15.5
193	71.5	89.4	129	43.1	53.8	66	15.1	18.8	3	12.8	16.1
192	71.1	88.8	128	42.6	53.3	65	14.6	18.3	2	13.3	16.6
191	70.6	88.3	127	42.2	52.7	64	14.2	17.7	1	13.7	17.2
190	70.2	87.7	126	41.7	52.2	63	13.7	17.2	0	14.2	17.7
189	69.7	87.2	125	41.3	51.6	62	13.3	16.6	1	14.6	18.3
188	69.3	86.6	124	40.8	51.1	61	12.8	16.1	2	15.1	18.8
187	68.8	86.1	123	40.4	50.5	60	12.4	15.5	3	15.5	19.4
186	68.4	85.5	122	40	50	59	12	15	4	16	20
185	68	85	121	39.5	49.4	58	11.5	14.4	5	16.4	20.5
184	67.5	84.4	120	39.1	48.8	57	11.1	13.8	6	16.8	21.1
183	67.1	83 8	119	38.6	48.3	56	10.6	13.3	7	17.3	21.6
182	66.6	83.3	118	38.2	47.7	55	10.2	12.7	8	17.7	22.2
181	66.2	82.7	117	37.7	47.2	54	9.7	12.2	9	18.2	22.7
180	65.7	82.2	116	37.3	46.6	53	9.3	11.6	10	18.6	23.3
179	65.3	81.6	115	36.8	46.1	52	8.8	11.1	11	19.1	23.8
178	64.8	81.1	114	36.4	45.5	51	8.4	10.5	12	19.5	24.4
177	64.4	80.5	113	36	45	50	8	10	13	20	25
176	64	80	112	35.5	44.4	49	7.5	9.4	14	20.4	25.5
175	63.5	79.4	111	35.1	43.8	48	7.1	8.8	15	20.8	26.1
174	63.1	78.8	110	34.6	43.3	47	6.6	8.3	16	21.3	26.6
173	62.6	78.3	109	34.2	42.7	46	6.2	7.7	17	21.7	27.2
172	62.2	77.7	108	33.7	42.2	45	5.7	7.2	18	22.2	27.7
171	61.7	77.2	107	33.3	41.6	44	5.3	6.6	19	22.6	28.3
170	61.3	76.6	106	32.8	41.1	43	4.8	6.1	20	23.1	28.8
169	60.8	76.1	105	32.4	40.5	42	4.4	5.5	21	23.5	29.4
168	60.4	75.5	104	32	40	41	4	5	22	24	30
167	60	75	103	31.5	39.4	40	3.5	4.4	23	24.4	30.5
166	59.5	74.4	102	31.1	38.8	39	3.1	3.8	24	24.8	31.1
165	59.1	73.8	101	30.6	38.3	38	2.6	3.3	25	25.3	31.6
164	58.6	73.3	100	30.2	37.7	37	2.2	2.7	26	25.7	32.2
163	58.2	72.7	99	29.7	37.2	36	1.7	2.2	27	26.2	32.7
162	57.7	72.2	98	29.3	36.6	35	1.3	1.6	28	26.6	33.3
161	57.3	71.6	97	28.8	36.1	34	0.8	1.1	29	27.1	33.8
160	56.8	71.1	96	28.4	35.5	33	0.4	0.5	30	27.5	34.4
159	56.4	70.5	95	28.0	35	32	0	0	31	28	35
158	56	70	94	27.5	34.4	31	0.4	0.5	32	28.4	35.5
157	55.5	69.4	93	27.1	33.8	30	0.8	1.1	33	28.8	36.1
156	55.1	68.8	92	26.6	33.3	29	1.3	1.6	34	29.3	36.6
155	54.6	68.3	91	26.2	32.7	28	1.7	2.2	35	29.7	37.2
154	54.2	67.7	90	25.7	32.2	27	2.2	2.7	36	30.2	37.7
153	53.7	67.2	89	25.3	31.6	26	2.6	3.3	37	30.6	38.3
152	53.3	66.6	88	24.8	31.1	25	3.1	3.8	38	31.1	38.8
151	52.8	66.1	87	24.4	30.5	24	3.5	4.4	39	31.5	29.4
150	52.4	65.5	86	24	30	23	4	5	40	32	40
149	52	65									

* TABLE VII.—*Of the Elastic Force of the Vapour of Water in inches of Mercury, by* Dr. URE.

Temp.	Force.	Temp.	Force.	Temp.	Force.	Temp.	Force.	Temp.	Force.	Temp.	Force.
24°	0.170	115°	2.820	195°	21.100	242°	53.600	270°	86.300	295.6°	130.400
32	0.200	120	3.300	200	23.600	245	56.340	271.2	88.000	295	129.000
40	0.250	125	3.830	205	25.900	245.8	57.100	273.7	91.200	297.1	133.900
50	0.360	130	4.366	210	28.880	248.5	60.400	275	93.480	298.8	137.400
55	0.416	135	5.070	212	30.000	250	61.900	275.7	94.600	300	139.700
60	0.516	140	5.770	216.6	33.400	251.6	63.500	277.9	97.800	300.6	140.900
65	0.630	145	6.600	220	35.540	254.5	66.700	279.5	101.600	302	144.300
70	0.726	150	7.530	221.6	36.700	255	67.250	280	101.900	303.8	147.700
75	0.860	155	8.500	225	39.110	257.5	69.800	281.8	104.400	305	150.560
80	1.010	160	9.600	226.3	40.100	260	72.300	283.8	107.700	306.8	154.400
85	1.170	165	10.800	230	43.100	260.4	72.800	285.2	112.200	308	157.700
90	1.360	170	12.050	230.5	43.500	262.8	75.900	287.2	114.800	310	161.300
95	1.640	175	13.550	234.5	46.800	264.9	77.900	289	118.200	311.4	164.800
100	1.860	180	15.160	235	47.220	265	78.040	290	120.150	312	167.000
105	2.100	185	16.900	238.5	50.300	267	81.900	292.3	123.100	*Another exper.*	
110	2.456	190	19.000	240	51.700	269	84.900	294	126.700	312°	165.5

* TABLE VIII.—*Of the Elastic Forces of the Vapours of Alcohol, Ether, Oil of Turpentine, and Petroleum, or Naphtha, by* Dr. URE.

Ether.

Temp.	*Force of Vapour.*
34°	6.20
44	8.10
54	10.30
64	13.00
74	16.10
84	20.00
94	24.70
104	30.00

2d. Ether.

Temp.	*Force of Vapour.*
105°	30.00
110	32.54
115	35.90
120	39.47
125	43.24
130	47.14
135	51.90
140	56.90
145	62.10
150	67.60
155	73.60
160	80.30
165	86.40
170	92.80
175	99.10
180	108.30
185	116 10
190	124.80
195	133.70
200	142.80
205	151.30
210	166.00

Alcoh. sp. gr. 0.813.

Temp.	*Force of Vapour.*
32°	0.40
40	0.56
45	0.70
50	0.86
55	1.00
60	1.23
65	1.49
70	1.76
75	2.10
80	2.45
85	2.93
90	3.40
95	3.90
100	4.50
105	5.20
110	6.00
115	7.10
120	8.10
125	9.25
130	10.60
135	12.15
140	13.90
145	15.95
150	18.00
155	20.30
160	22.60
165	25.40
170	28.30
173	30.00
178.3	33.50
180	34.73
182.3	36.40
185.3	39.90
190	43.20

Alcoh. sp. gr. 0.813.

Temp.	*Force of Vapour.*
193.3°	46.60
196.3	50.10
200	53.00
206	60.10
210	65.00
214	69.30
216	72.20
220	78.50
225	87.50
230	94.10
232	97.10
236	103.60
238	106.90
240	111.24
244	118.20
247	122.10
248	126.10
249.7	131.40
250	132.30
252	138.60
254.3	143.70
258.6	151.60
260	155 20
262	161.40
264	166.10

Petroleum.

Temp.	*Force of Vapour.*
316°	30.00
320	31.70
325	34.00
330	36.40
335	38.90
340	41.60
345	44.10
350	46.86
355	50.20
360	53.30
365	56.90
370	60.70
372	61.90
375	64.00

Oil of Turpen.

Temp.	*Force of Vapour.*
304°	30.00
307.6	32.60
310	33.50
315	35.20
320	37.06
322	37.80
326	40.20
330	42.10
336	45.00
340	47.30
343	49.40
347	51.70
350	53.80
354	56.60
357	58.70
360	60.80
362	62.40

* TABLE IX.—*New French Weights and Measures* (*calculated by* Dr. DUNCAN, *jun.*)

1.—*Measures of Length: the Metre being at 32°, and the Feet at 62°.*

		English inches.		*Mil.*	*Fur.*	*Yds.*	*Feet.*	*In.*
Millimetre	=	.03937						
Centimetre	=	.39371						
Decimetre	=	3.93710						
Metre‡	=	39.37100						
Decametre	=	393.71000	=	0	0	10	2	9.7
Hecatometre	=	3937.10000	=	0	0	109	1	1
Kilometre	=	39371.00000	=	0	4	213	1	10.2
Myriometre	=	393710.00000	=	6	1	156	0	6

2.—*Measures of Capacity.*

		Cubic inches.		*English.*			
				Tons.	*Hhds.*	*Wine. G.*	*Pints.*
Millilitre	=	.06103					
Centilitre	=	.61028					
Decilitre	=	6.10280					
Litre	=	61 02800	=	0	0	0.	2.1133
Decalitre	=	610.28000	=	0	0	2.	5.1352
Hecatolitre	=	6102.80000	=	0	0	26.419	
Kilolitre	=	61028.00000	=	1	0	12.19	
Myriolitre	=	610280.00000	=	10	1	58.9	

3.—*Measures of Weight.*

		English Grains.		*Avoirdupois.*		
				Poun.	*Oun.*	*Dram.*
Milligramme	=	.0154				
Centigramme	=	.1544				
Decigramme	=	1.5444				
Gramme	=	15.4440				
Decagramme	=	154.4402	=	0	0	5.65
Hecatogramme	=	1544.4023	=	0	3	8.5
Kilogramme	=	15444.0234	=	2	3	5
Myriogramme	=	154440.2344	=	22	1	2

* TABLE X.—*Correspondence of English Weights and Measures with those used in France before the Revolution.*

§ 1.—*Weights.*

The Paris pound, *poids de marc* of Charlemagne, contains 9216 Paris grains; it is divided into 16 ounces, each ounce into 8 gros, and each gros into 72 grains. It is equal to 7561 English troy grains.

The English troy pound of 12 ounces contains 5760 English troy grains, and is equal to 7021 Paris grains.

The English avoirdupois pound of 16 ounces contains 7000 English troy grains, and is equal to 8532.5 Paris grains.

To reduce Paris grains to English troy grains, divide by To reduce English troy grains to Paris grains, multiply by	1.2189
To reduce Paris ounces to English troy, divide by To reduce English troy ounces to Paris, multiply by	1.015734

§ 2.—*Long and Cubical Measures.*

To reduce Paris running feet, or inches, into English, multiply by English running feet, or inches, into Paris, divide by - -	1.065977
To reduce Paris cubic feet, or inches, to English, multiply by English cubic feet, or inches, to Paris, divide by - - -	1.211278

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‡ Recently determined by Capt. Kater to be 39.37079 inches. (*Phil. Trans.* 1818, *p.* 109.)

* TABLE XI—*Correspondence between English and other Foreign Weights and Measures.*

I.—*English Weights and Measures.*

Troy Weight.

Pound.	*Ounces.*	*Drms.*	*Scruples.*	*Grains.*	*Grammes.*
1	12	96	288	5760	372.96
	1	8	14	480	31.08
		1	3	60	3.885
			1	20	1.295
				1	0.06475

Avoirdupois Weight.

Pound.	*Ounces.*	*Drms.*	*Grains.*	*Grammes.*
1	16	256	7000.	453.25
	1	16	437.5	28.328
		1	27.34375	1.7705

Measures.

Gal.	*Pints.*	*Ounces.*	*Drms.*	*Cubic. Inch.*	*Litres.*
1	8	128	1024	231.	3.78515
	1	16	128	28.875	0.47398
		1	8	1.8047	0.02957
			1	0.2256	0.00396

N. B.—The English ale-gallon contains 282 cubical inches.
The wine gallon contains 58176 Troy grains; and the wine pint 7272 Troy grains.

II.—*German.*

71 lbs. or grs. English troy - - = 74 lbs. or grs. German apothecaries' weight.
1 oz. Nuremberg, medic. weight = 7 dr. 2 sc. 9 gr. English.
1 mark Cologne - - - - - - = 7 oz. 2 dwt. 4 gr. English troy.

III.—*Dutch.*

1 lb. Dutch = 1 lb. 3 oz. 16 dwt. 7 gr. English troy.
787½ lbs. Dutch = 1038 lbs. English troy.

IV.—*Swedish Weights and Measures, used by Bergmann and Scheele.*

The Swedish pound, which is divided like the English apothecary or troy pound, weighs 6556 grs. troy.

The kanne of pure water, according to Bergmann, weighs 42250 Swedish grains and occupies 100 Swedish cubical inches. Hence the kanne of pure water weighs 48088.719444 English troy grains, or is equal to 189.9413 English cubic inches; and the Swedish longitudinal inch is equal to 1.238435 English longitudinal inches.

By Everard's experiment, and the proportions of the English and French foot, as established by the Royal Society and French Academy of Sciences, the following numbers are ascertained:

Paris grains in a Paris cube foot of water at 55° F. = 645511
English grains in a Paris cube foot of water - - = 529922
Paris grains in an English cube foot of water - = 533247
English grains in an English cube foot of water = 437489.4
English grains in an English cube inch of water = 253.175

As a cubic foot of water weighs very nearly 1000 ounces avoirdupois, the specific gravities of bodies express the ounces in a cubic foot of them, the density of water being called 1000.

* TABLE XII.—*Of the Solubility of some Solids in Water.*

NAMES OF SALTS.	Solubility in 100 Parts Water.	
	At 60°	At 212°
Acids.		
Arsenic	150.	
Benzoic	0.208	4.17
Boracic		2.
Camphoric	1.04	8.3
Citric	133.	200.
Gallic	8.3	66.
Mucic	0.84	1.25
Molybdenic		0.1
Oxalic	50.	100.
Suberic	0.69	50.
Succinic	4.	50.
Tartaric	Very soluble	
Salifiable Bases.		
Barytes	5.	50.
crystallized	57.	Unlimited
Lime	0.2	
Potash	Very soluble	
Soda	do.	
Strontites	0.6	
crystallized	1.9	50.
Salts.		
Acetate of ammonia	Very soluble	
barytes	do.	
lime	do.	
magnesia	do.	
potash	100.	
soda	Very soluble	
strontites		40.
Carbonate of ammonia	+ 30.	100.
barytes	Insoluble	
lime	do.	
magnesia	2.	
potash	25.	83.
soda	50.	+ 100.
strontites	Insoluble	
Camphorate of ammonia	1.	33.
barytes	0.16	
lime	0.5	
potash	33.	+ 33.
Citrate of soda	60.	
lime	Insoluble	
Chlorate of barytes	25.	+ 25.
mercury	25.	
potash	6.	40.
soda	35.	+ 35.
Muriate of ammonia	33.	100.
barytes	20.	+ 20.
lead	4.5	
lime	200.	
magnesia	100.	
mercury	5.	50.
potash	33.	
silver	$0.\frac{1}{30}$	

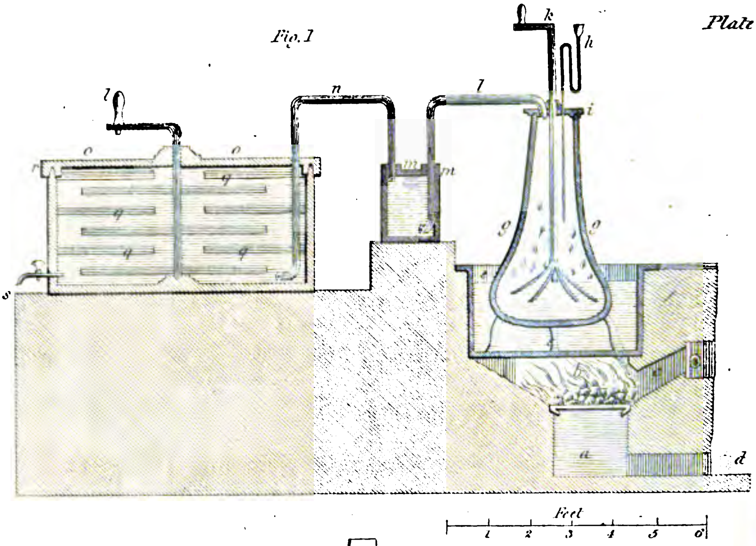
NAMES OF SALTS.	Solubility in 100 Parts Water.	
	At 60°	At 212°
Muriate of soda	35.42	36.16
strontites	150.	Unlimited
Nitrate of ammonia	50.	200.
barytes	8.	25.
lime	400.	
magnesia	100.	+ 100.
potash	14.25	100.
soda	33.	+ 100.
strontites	100.	200.
Oxalate of strontites	0.$\frac{1}{19}$	
Phosphate of ammonia	25.	+ 25.
barytes	0.	0.
lime	0.	0.
magnesia	6.6	
potash	Very soluble	
soda	25.	50.
strontites	0.	0.
Phosphite of ammonia	50.	+ 50.
barytes	0.$\frac{1}{4}$	
potash	33.	+ 33.
Sulphate of ammonia	50.	100.
barytes	0.002	
copper	25.	50.
iron	50.	+ 100.
lead	0.$\frac{1}{12}$	
lime	0.2	0.22
magnesia	100.	133.
potash	6.25	20.
soda	37.	125.
strontites	0.	0.02
Sulphite of ammonia	100.	
lime	0.125	
magnesia	5.	
potash	100.	
soda	25.	100.
Saccholactate of potash		12.
soda		20.
Sub-borate of soda (borax)	8.4	16.8
Super-sulphate of alumina & potash (alum)	5.	133.
potash	50.	+ 100.
Super-oxalate of potash		10.
tartrate of potash	1.$\frac{1}{2}$	3.$\frac{1}{3}$
Tartrate of potash	25.	
and soda	20.	
antimony and potash	6.6	33.

See Salt.

CHEMICAL APPARATUS

Plate

Fig. 1



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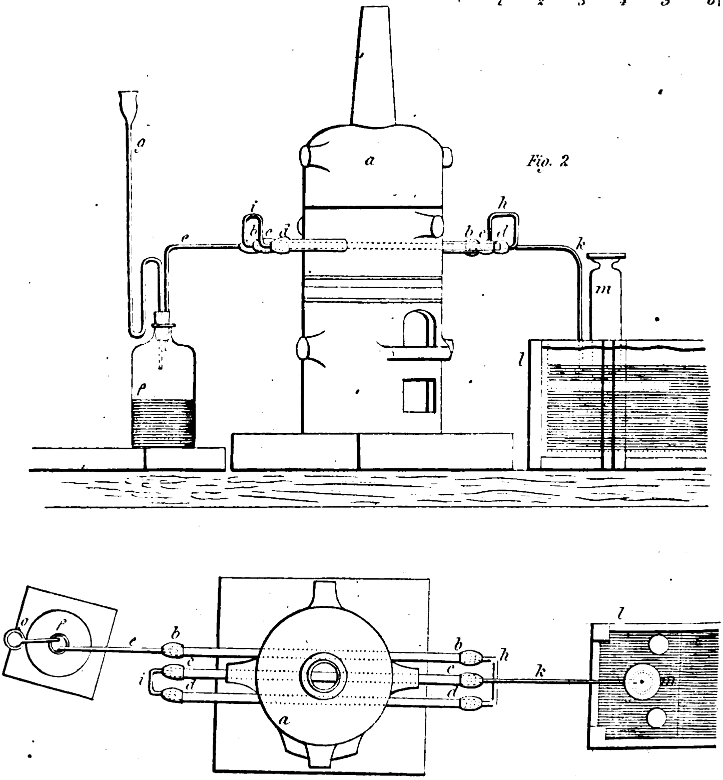

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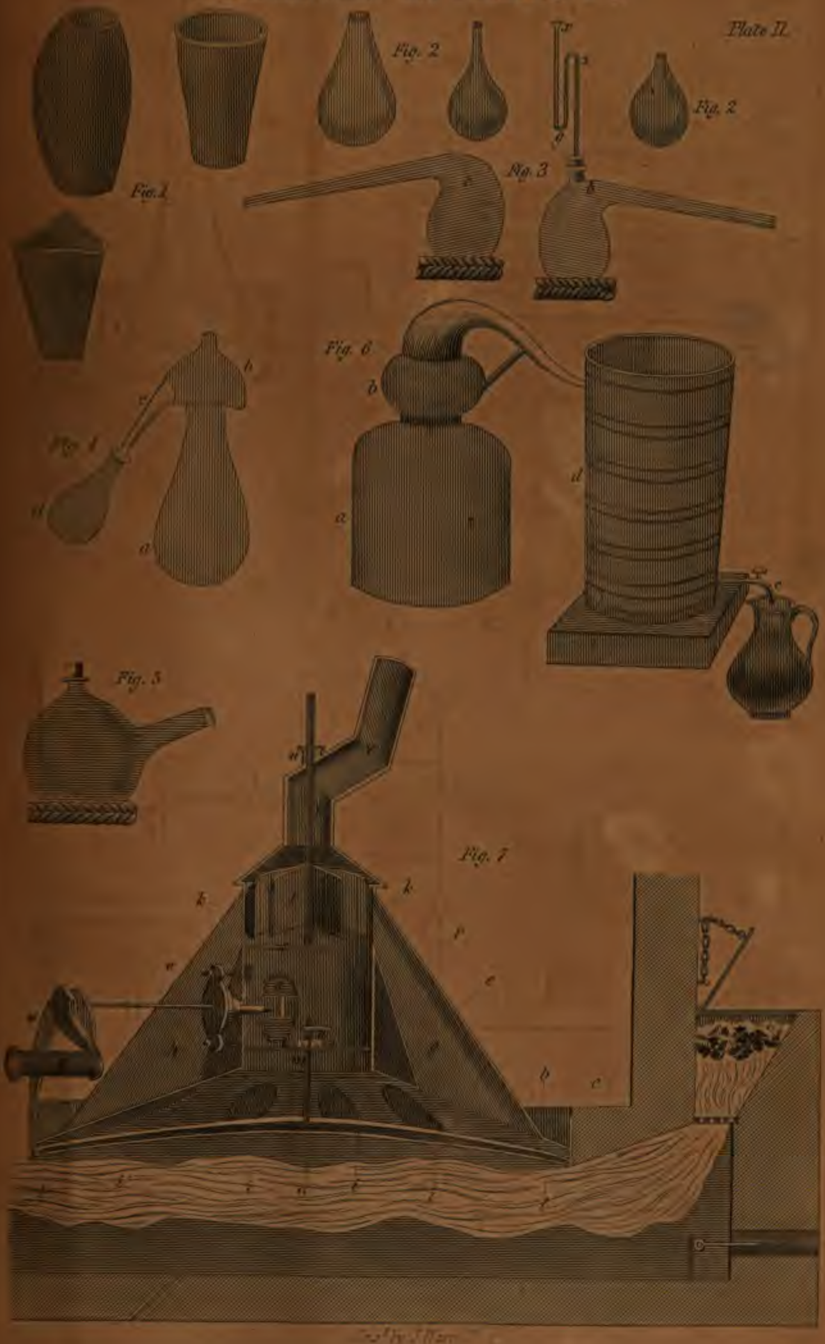
CHEMICAL APPARATUS

Plate II.



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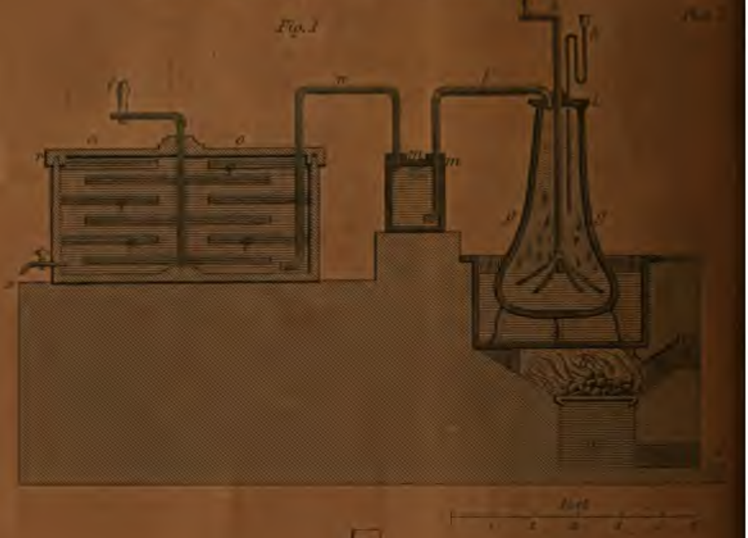
CHEMICAL APPARATUS

Fig. 1



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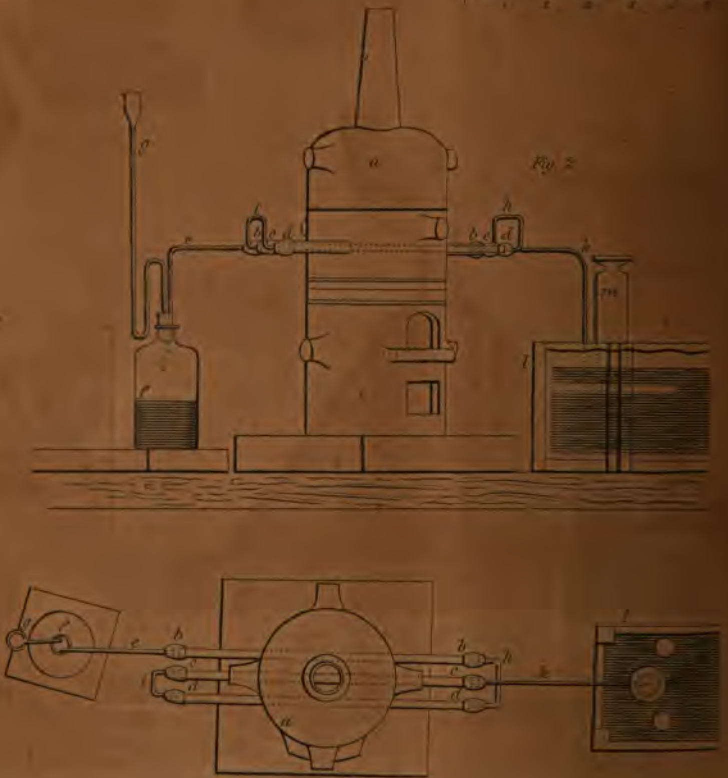

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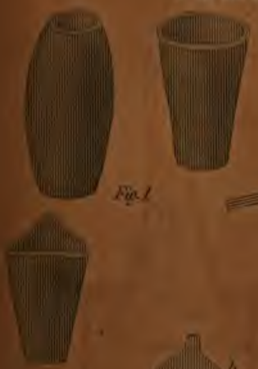
CHEMICAL APPARATUS

Plate II.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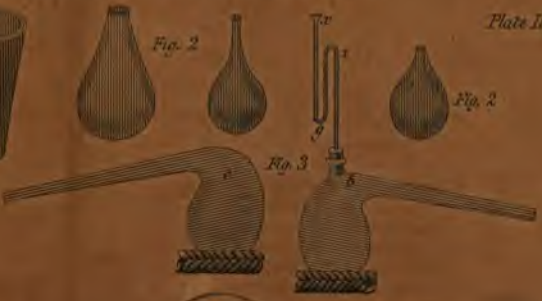
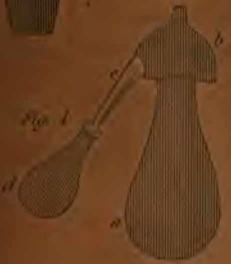


Fig. 2

Fig. 2

Fig. 3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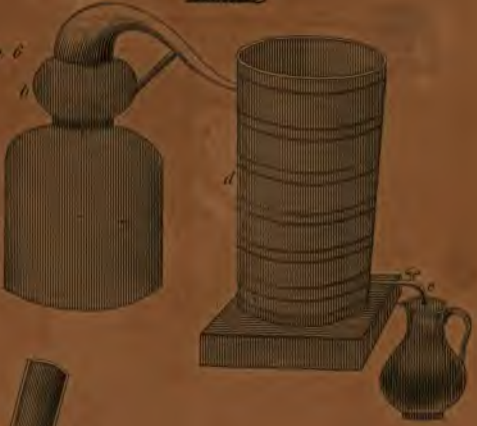
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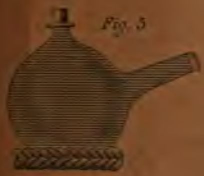
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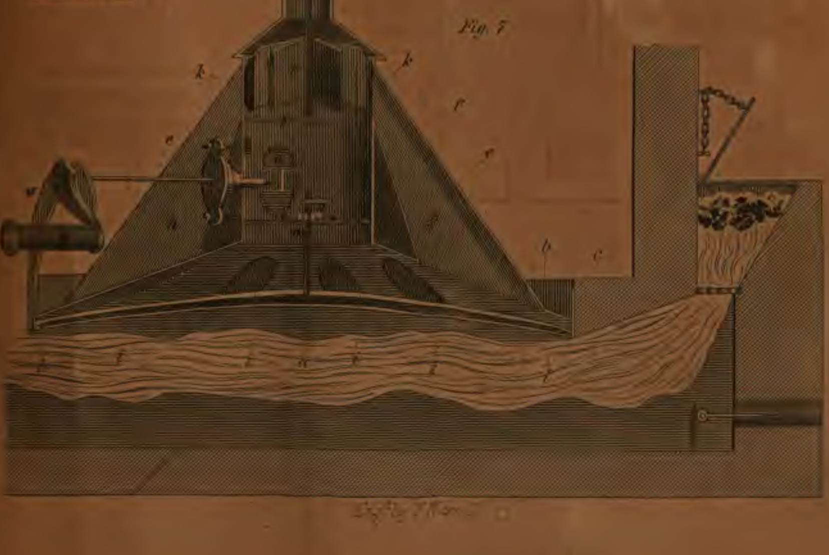
Fig. 7

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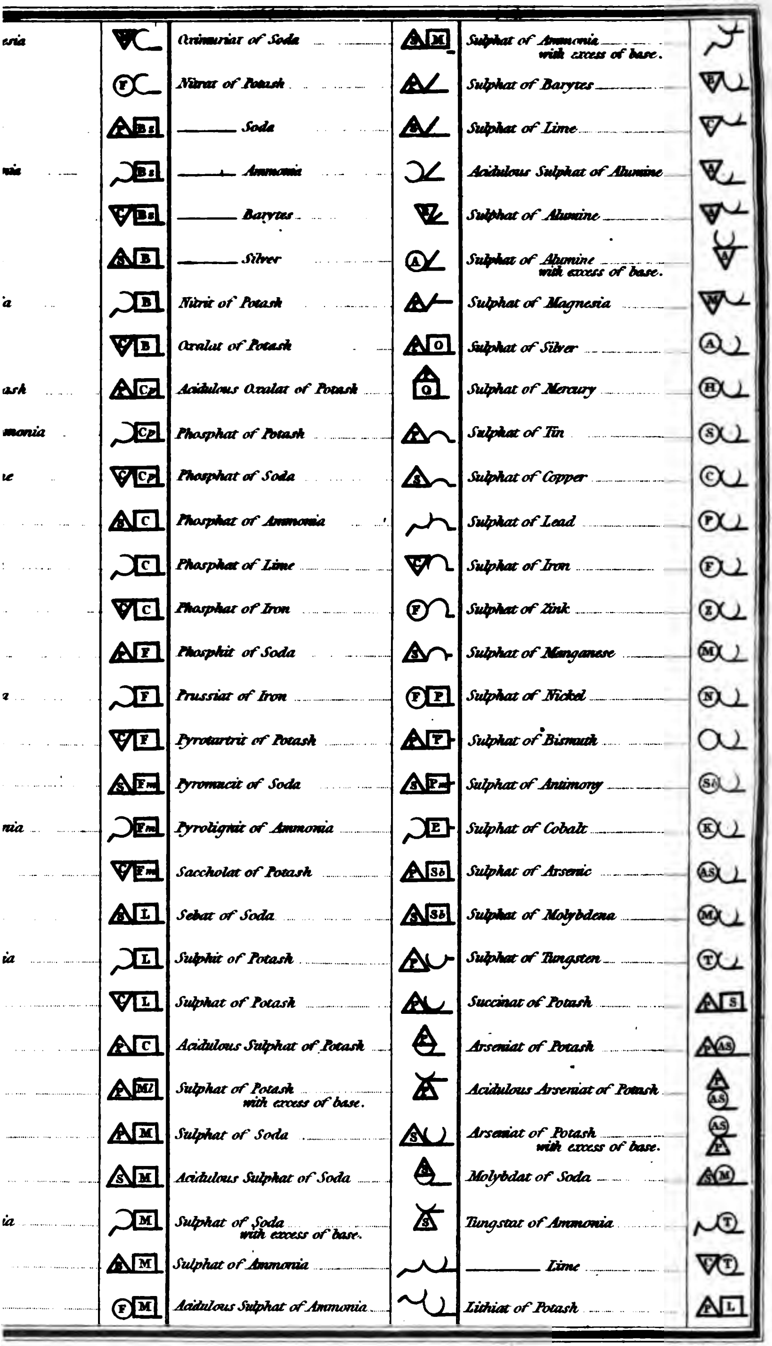
Plate IV. Continued.



esia	Oximuriat of Soda	Sulphat of Ammonia with excess of base.
	Nitrat of Potash	Sulphat of Barytes
	——— Soda	Sulphat of Lime
nia	——— Ammonia	Acidulous Sulphat of Alumine
	——— Barytes	Sulphat of Alumine
	——— Silver	Sulphat of Alumine with excess of base.
a	Nitrit of Potash	Sulphat of Magnesia
	Oxalat of Potash	Sulphat of Silver
ash	Acidulous Oxalat of Potash	Sulphat of Mercury
monia	Phosphat of Potash	Sulphat of Tin
te	Phosphat of Soda	Sulphat of Copper
	Phosphat of Ammonia	Sulphat of Lead
	Phosphat of Lime	Sulphat of Iron
	Phosphat of Iron	Sulphat of Zink
	Phosphit of Soda	Sulphat of Manganese
a	Prussiat of Iron	Sulphat of Nickel
	Pyrotartrit of Potash	Sulphat of Bismuth
	Pyromucit of Soda	Sulphat of Antimony
nia	Pyrolignit of Ammonia	Sulphat of Cobalt
	Saccholat of Potash	Sulphat of Arsenic
	Sebat of Soda	Sulphat of Molybdena
ia	Sulphit of Potash	Sulphat of Tungsten
	Sulphat of Potash	Succinat of Potash
	Acidulous Sulphat of Potash	Arseniat of Potash
	Sulphat of Potash with excess of base.	Acidulous Arseniat of Potash
	Sulphat of Soda	Arseniat of Potash with excess of base.
	Acidulous Sulphat of Soda	Molybdat of Soda
ia	Sulphat of Soda with excess of base.	Tungstat of Ammonia
	Sulphat of Ammonia	——— Lime
	Acidulous Sulphat of Ammonia	Lithiat of Potash

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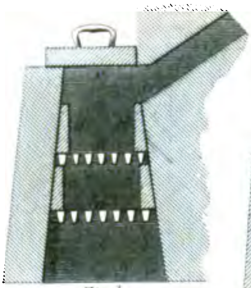
CHEMICAL APPARATUS

Plate



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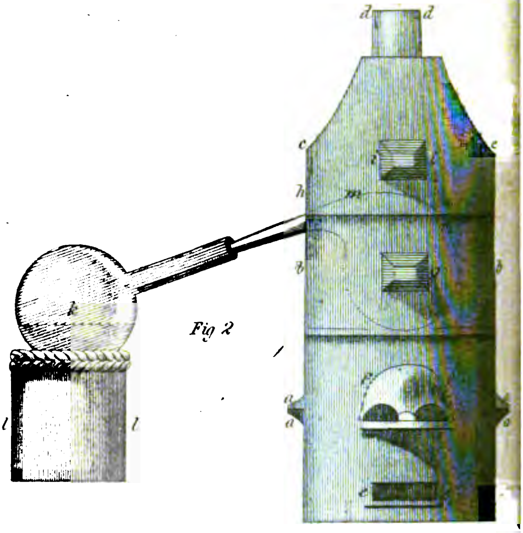

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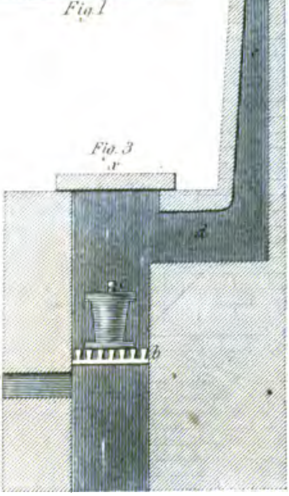

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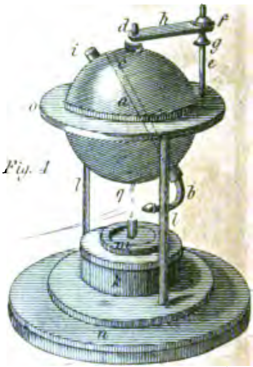

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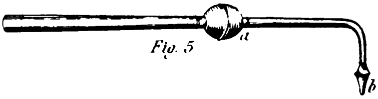

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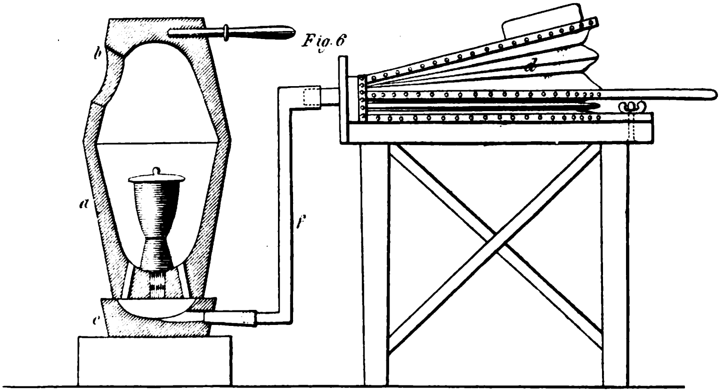

Fig. 6

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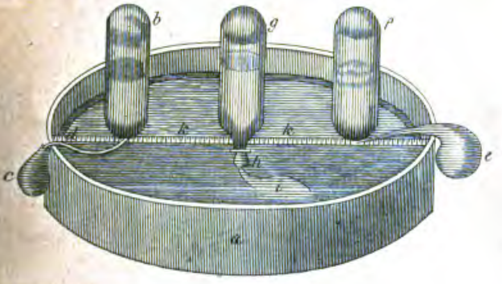
CHEMICAL APPARATUS

Plate VI.

Fig. 1



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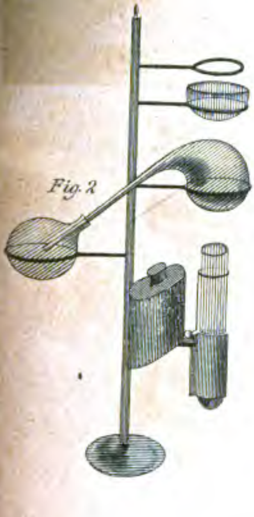
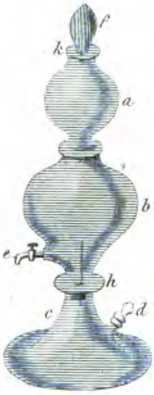


Fig. 3

Fig. 4



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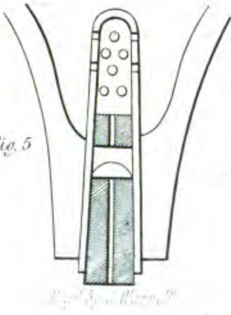

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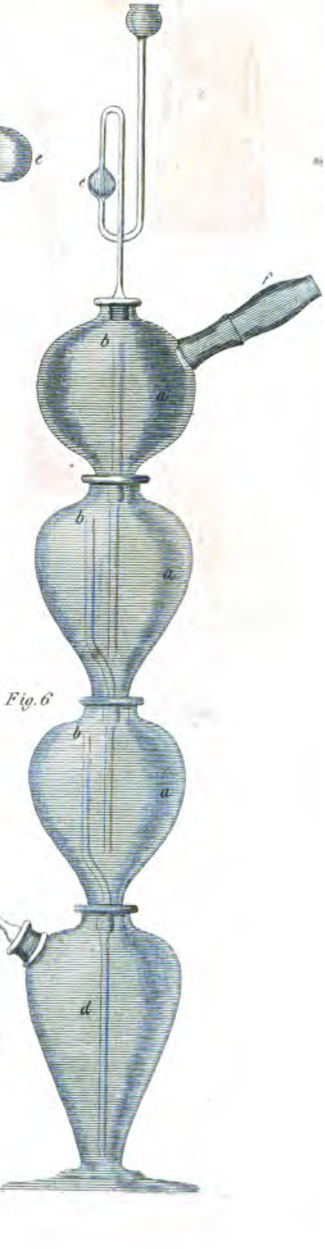

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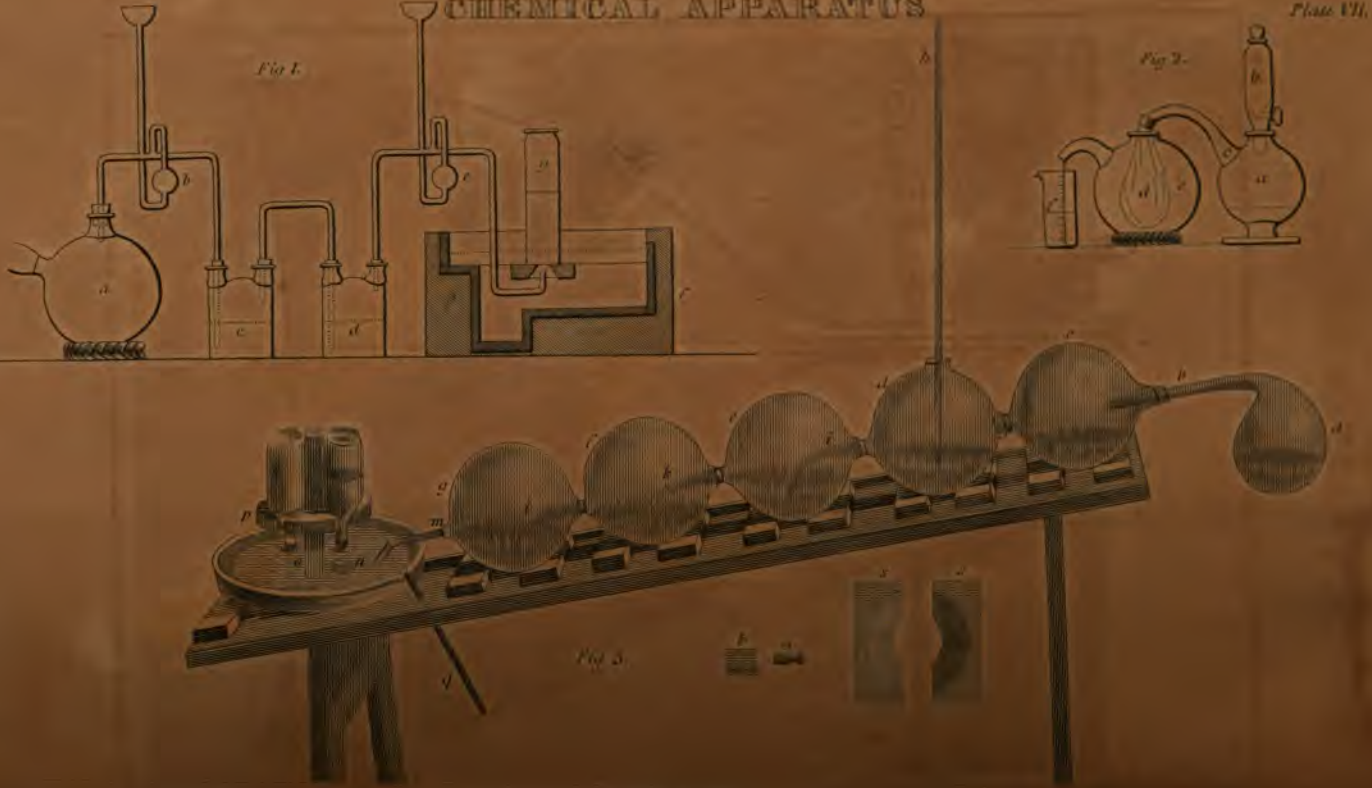
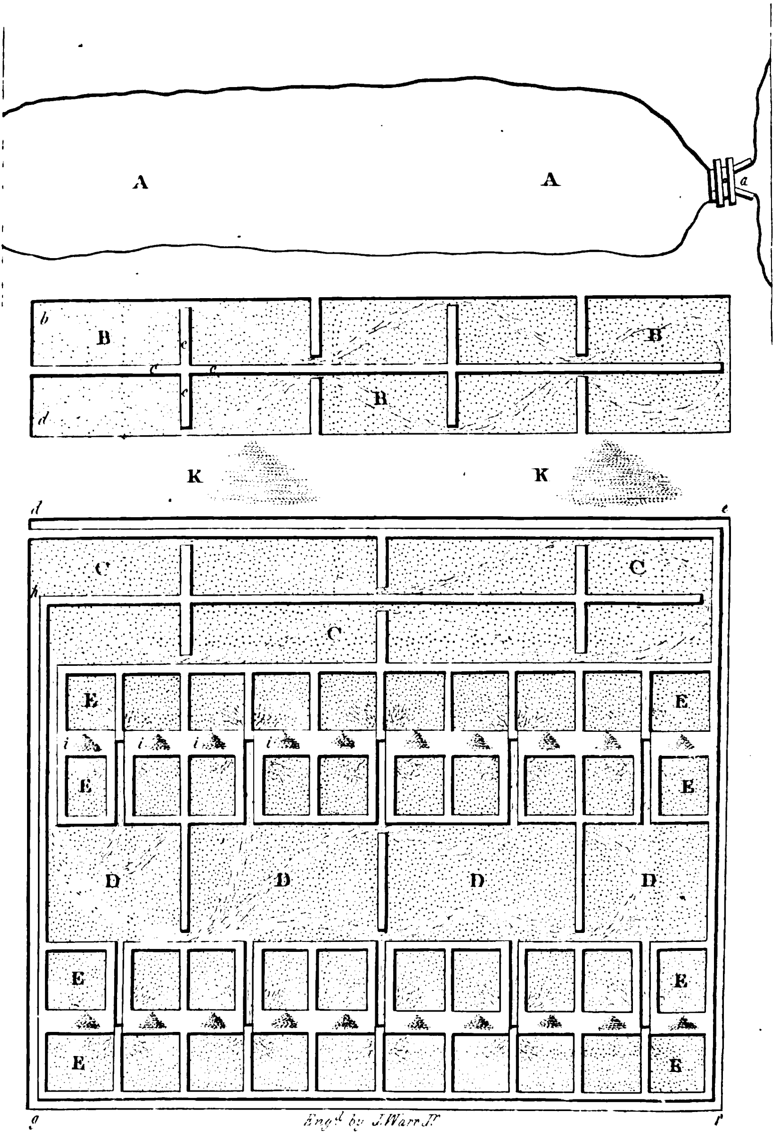
Plate VII.

CHEMICAL APPARATUS



BRINE PITS



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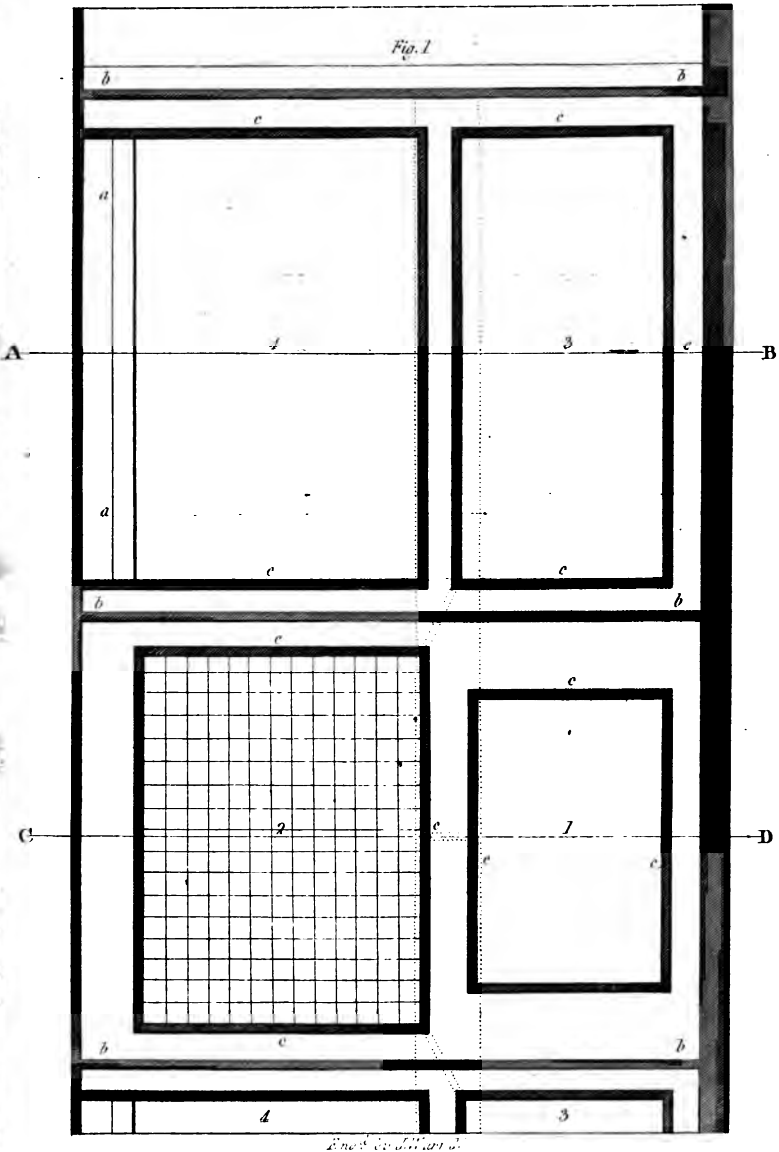
SALT WORKS

Plate X.

Evaporating Pans



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SALT WORKS

Bavarian Method of evaporating Salt Waters.

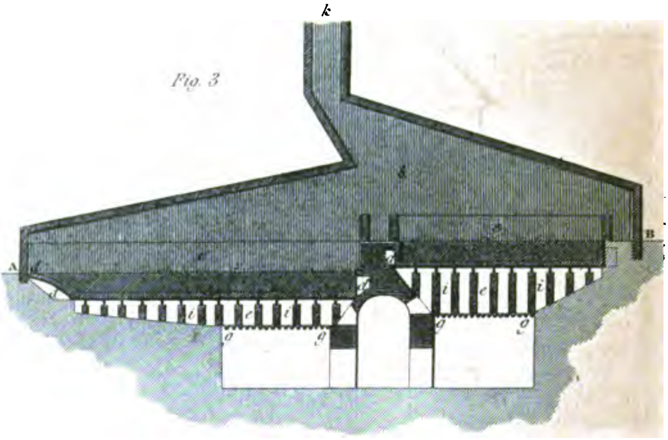
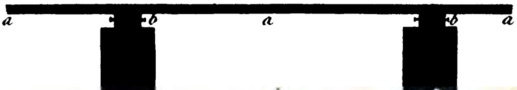


Fig. 4



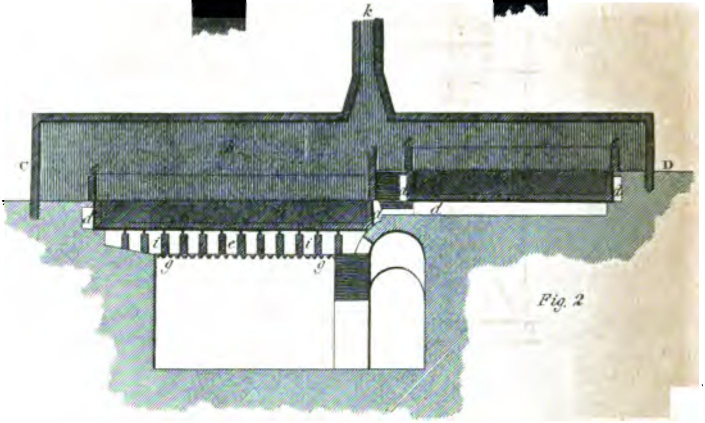


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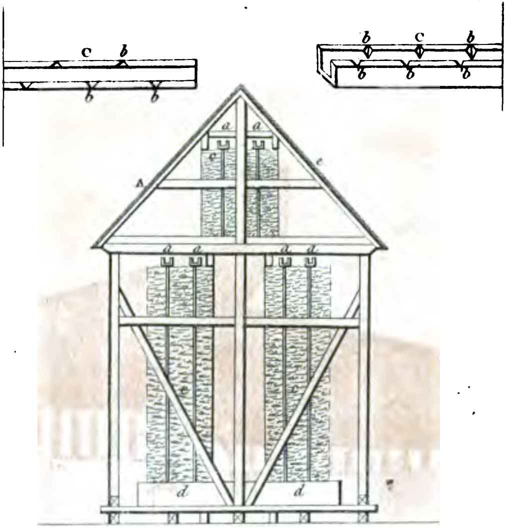
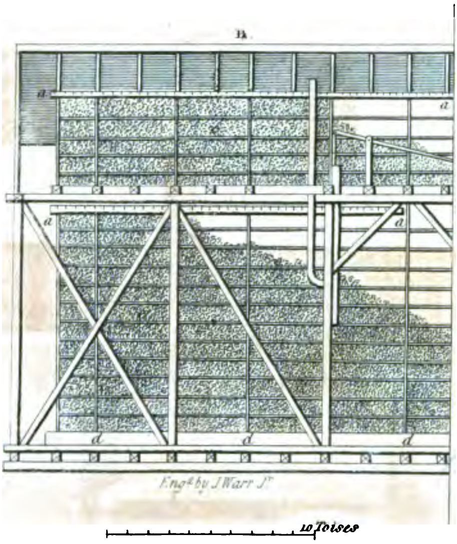
Plate XII

SALT WORKS

Graduation house





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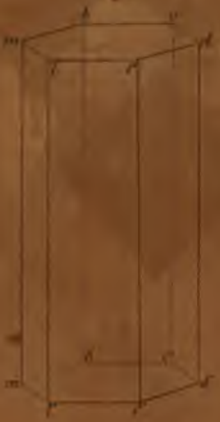

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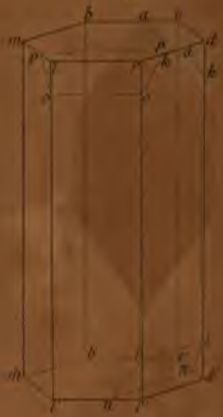

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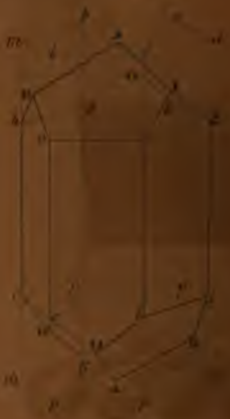

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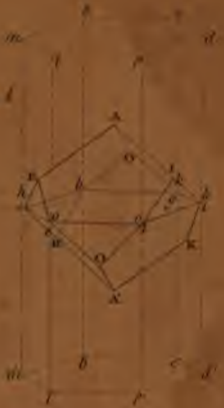

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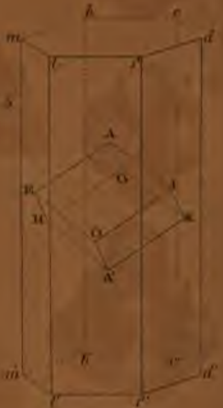

Fig. 6

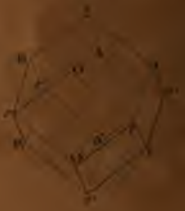

Fig. 7

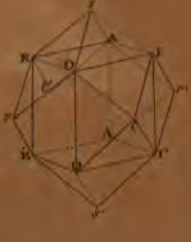

Fig. 8

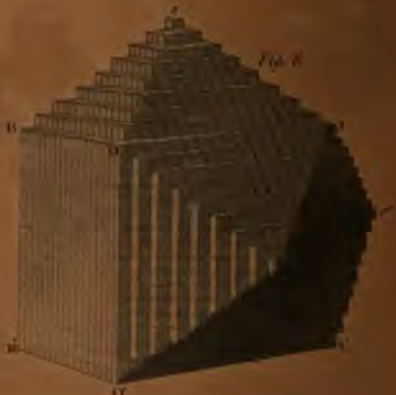

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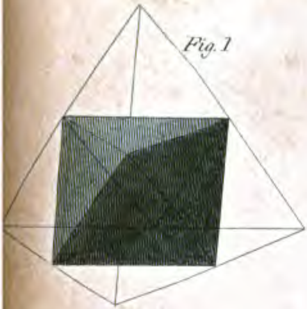
Plate XIV

Fig. 1



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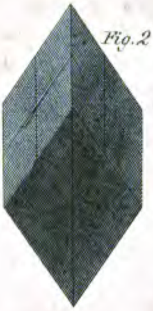

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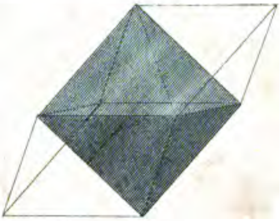

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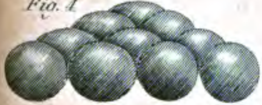


Fig. 5

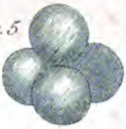
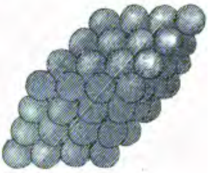


Fig. 11



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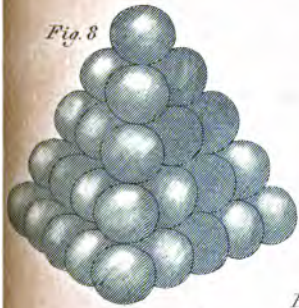


Fig. 6

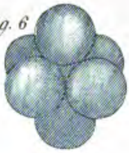


Fig. 15

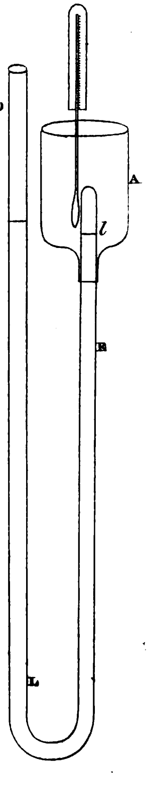


Fig. 7

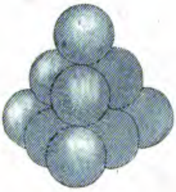
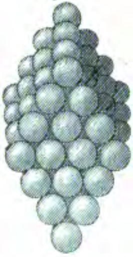


Fig. 10



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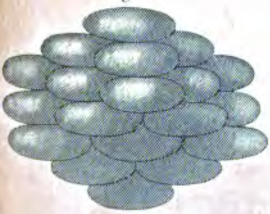

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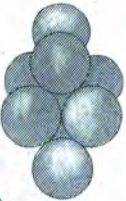

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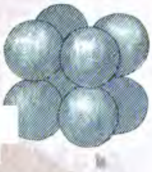
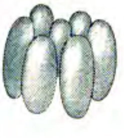


Fig. 13



Engd by J. Warr Jr

EXPLANATION OF THE PLATES,

ADDED TO THE AMERICAN EDITION.

CALORIMOTOR.—Plate 15.

A *a*, Fig. 1. two cubical vessels, 20 inches square, inside *b b b b* a frame of wood containing 20 sheets of copper, and 20 sheets of zinc, alternating with each other, and about half an inchapart. T T *t t*, masses of tin cast over the protruding edges of the sheets, which are to communicate with each other.

Fig. 2. Represents the mode in which the junction between the various sheets and tin masses is effected. Between the letters *z z*, the zinc only is in contact with the tin masses. Between *c c*, the copper alone touches. It may be observed, that, at the back of the frame, ten sheets of copper between *c c*, and ten sheets of zinc between *z z*, are made to communicate, by a common mass of tin extending the whole length of the frame, between T T: but in front, as in Fig. 1, there is an interstice between the mass of tin, connecting the ten copper sheets, and that connecting the ten zinc sheets. The screw forceps, appertaining to each of the tin masses, may be seen on either side of the interstice: and likewise a wire for ignition held between them. The application of the rope, pulley and weights is obvious. The swivel at S permits the frame to be swung round and lowered into water in the vessel *a*, to wash off the acid, which, after immersion in the other vessel, might continue to act on the sheets, encrusting them with oxide. Between *p p*, there is a wooden partition which is not necessary, though it may be beneficial.

Fig. 3. Represents a voltaic battery, in which hollow paralellopipeds of glass are substituted for porcelain troughs. The plates are suspended to bars counterpoised like window sashes. The advantages are, they are easily cleansed, are quite impervious, and easily replaced. They may be procured where porcelain cannot be had.

Dr. Hare's substitute for Woulfe's or Nooth's Apparatus for the impregnation of fluids with gas.—Plate 16.

Fig. 1. The gas proceeding from a retort, of which the beak is introduced into the mouth of the receiver at *m*, must deposite in this vessel much of any vapour by which it may be contaminated, and then passing down the trumpet-mouth tube, and through the contents of the innermost jar, afterwards may reach those of the intervening jar at *a*, and the external one at *b*, depressing the fluid successively below the feet F *f*, and thus exposing a larger surface for absorption. When desirable, a recurved tube may be affixed to the tubulure to carry off noxious effluvia.

The other figures are to explain an apparatus on the same principle, constructed of hollow, oblong paralellopipeds, differing in length more than in breadth; so as to allow a serpentine tube to wind into the interior, and deliver gas under a vessel shaped like a T.

Fig. 2. Represents a vertical section of the whole, as when situated for use.

Fig. 3. A vertical section of the lower vessels only.

Fig. 4. A vertical section of the covers alone.

Fig. 5. A horizontal section, or ground plan of the lower vessels. The upper vessels are so proportioned as to divide the distances between the lower ones equally.

Fig. 1. Sliding rod eudiometer or gas measurer, surmounted by its spheroidal recipient. r r, sliding rod graduated into twenty divisions, each subdivided into ten, so as to make two hundred parts. At m f, are male and female screws, (forming what mechanics call a stuffing box), by means of which a cork soaked in bees-wax and oil is compressed around the rod. At n, is the neck of the recipient, ground to fit the recurved tube which enters it. At S, is a screw, by which to close the capillary orifice of the recipient.

Fig. 2. Eudiometer upon the same principle, but made stouter in order to resist the explosion of inflammable mixtures. W W, wire to be ignited.

Fig. 3. Displays a construction of the sliding rod, by which, when desirable, greater accuracy may be attained in the measurement of gas. A smaller rod of wire is made to slide within the larger. Whatever may be the ratio (in bulk) of the rods to each other, the lesser may be graduated to give thousandths, by ascertaining how far it must be moved to produce the effect of a movement of one division on the large rod, and dividing the observed distance into ten parts.

Fig. 4. Represents an apparatus adapted to explode an inflammable mixture, (see article Eudiometer); and so contrived as to be a substitute for the well known apparatus, in which an electrophorus is employed to ignite hydrogen gas. Moisture in the air suspends the action of that apparatus, but does not interfere with the one here represented.

A A, a cistern divided by a water-tight partition, which separates the holder G, from a calorimotor situated under C, and a plunger P, contained in the other part of it. W W, wires severally soldered to the different galvanic surfaces, and forked or slit at their ends, so as to embrace the wire of an eudiometer for the explosion of inflammable mixtures, (see article Eudiometer). At f f, are forceps (severally soldered in the same way) for holding a wire to be ignited by the galvanic influence.

These wires and the plates with which they are connected may be seen at fig. 5, where there is an enlarged drawing of the calorimotor and its wires.

It is supposed to be situated below the edge of the cistern, which is supplied with diluted acid reaching within a little distance of the plates.

c, a cock soldered to a pipe communicating with the inside of the gasometer. h h, a gallows and guide wire, for regulating the rise of the gasometer.

The construction of this will be better comprehended from fig. 6, where it represents the tray for holding the zinc, by means of which hydrogen is to be evolved. The tray is supported on the pipe in the axis of the vessel by a sliding band and screw, so that it may be raised or depressed at pleasure. When this tray is covered with granulated zinc, and the lower vessel is filled with acid so as to cover it, hydrogen must be generated until it occupies so much of the air-holder, as to depress the acid from off the zinc. Supposing the apparatus thus prepared, on depressing the plunger P. fig. 4, the acid in the cistern A A, will be forced up among the galvanic surfaces, and cause the wire at f f, to be ignited. Turning the cock while the wire is red-hot, the hydrogen will be emitted and inflamed.

New Eudiometers.—Plate 17.

Fig. 1. Sliding rod eudiometer or gas measurer, surmounted by its spheroidal recipient. r r, sliding rod graduated into twenty divisions, each subdivided into ten, so as to make two hundred parts. At m f, are male and female screws, (forming what mechanics call a stuffing box), by means of which a cork soaked in bees-wax and oil is compressed around the rod. At n, is the neck of the recipient, ground to fit the recurved tube which enters it. At S, is a screw, by which to close the capillary orifice of the recipient.

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CALORIMOTOR.

Plate XV

Fig. 4.

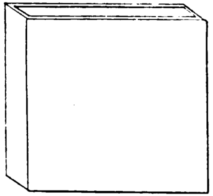

Fig. 1.

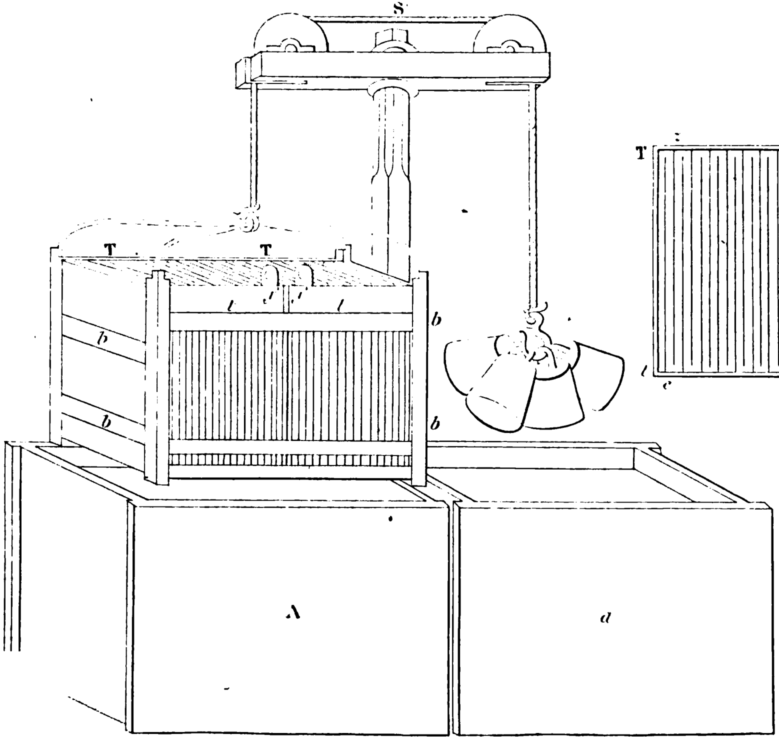

Fig. 2.

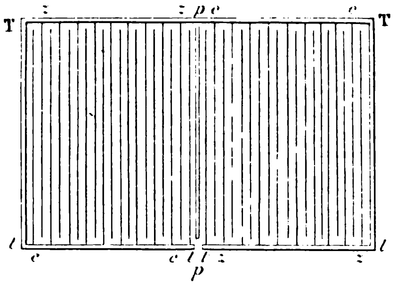

Fig. 3.

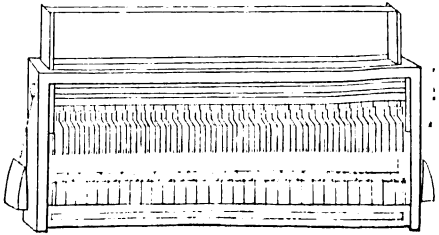

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Fig. 1.

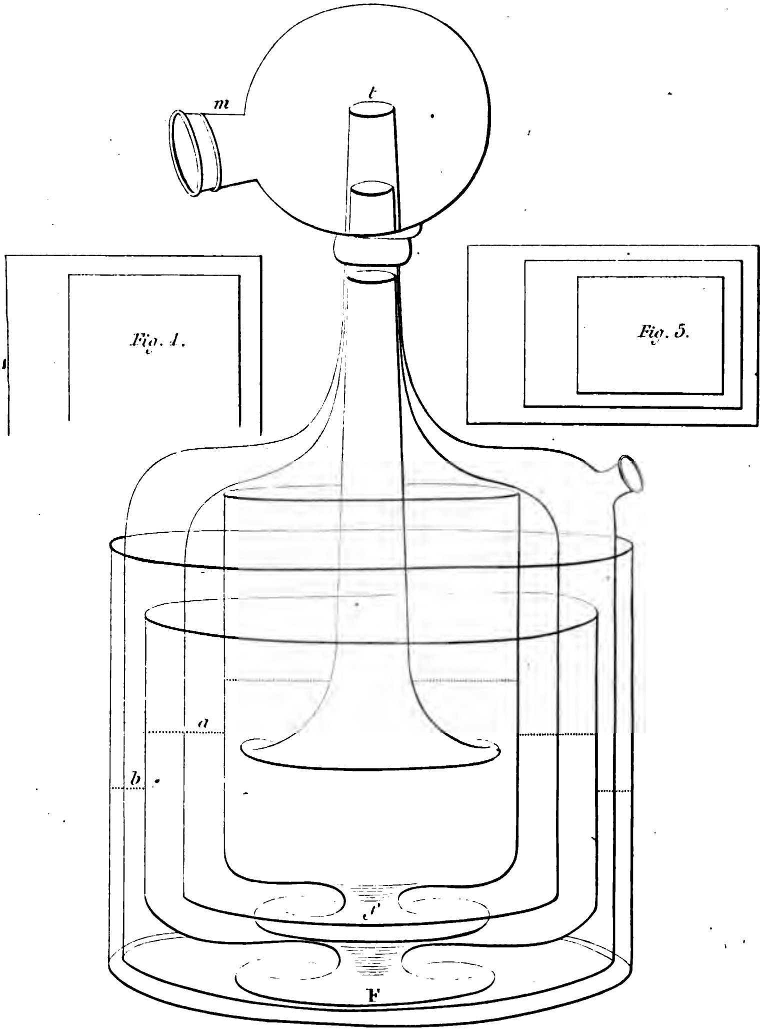

Fig. 4.

Fig. 5.

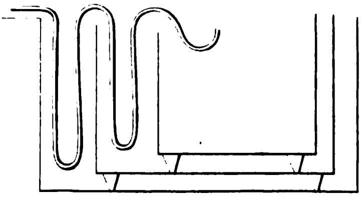

Fig. 3.

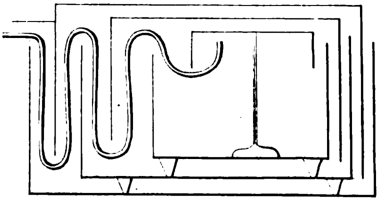

Fig. 2.

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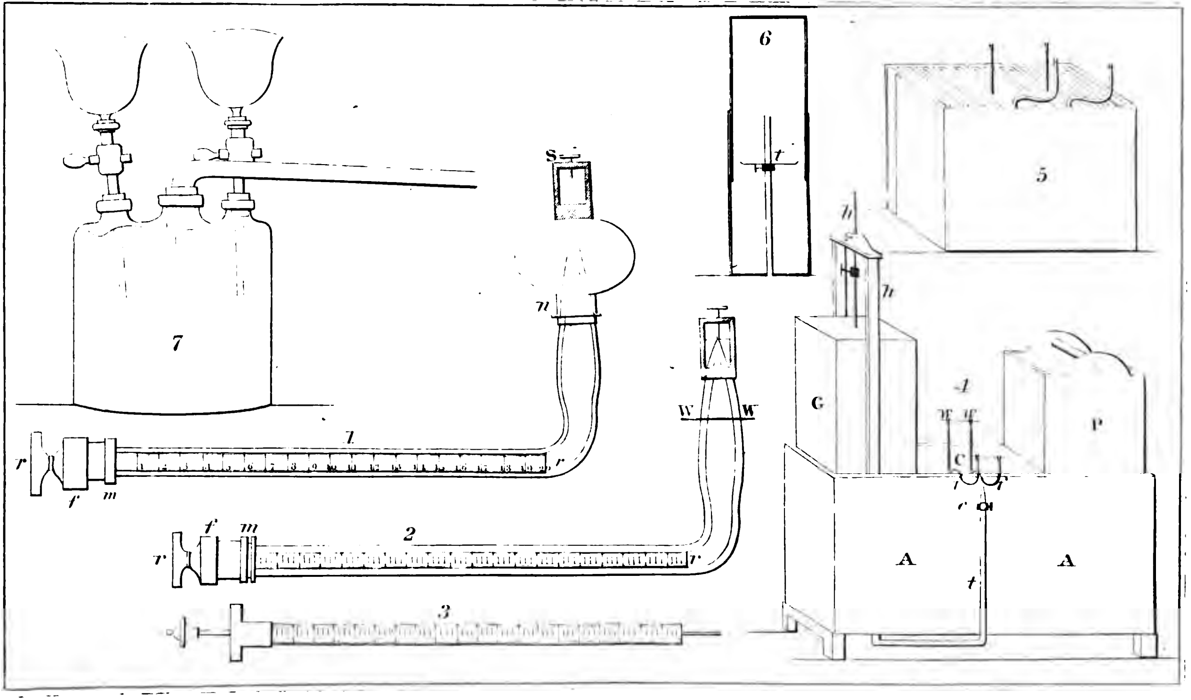
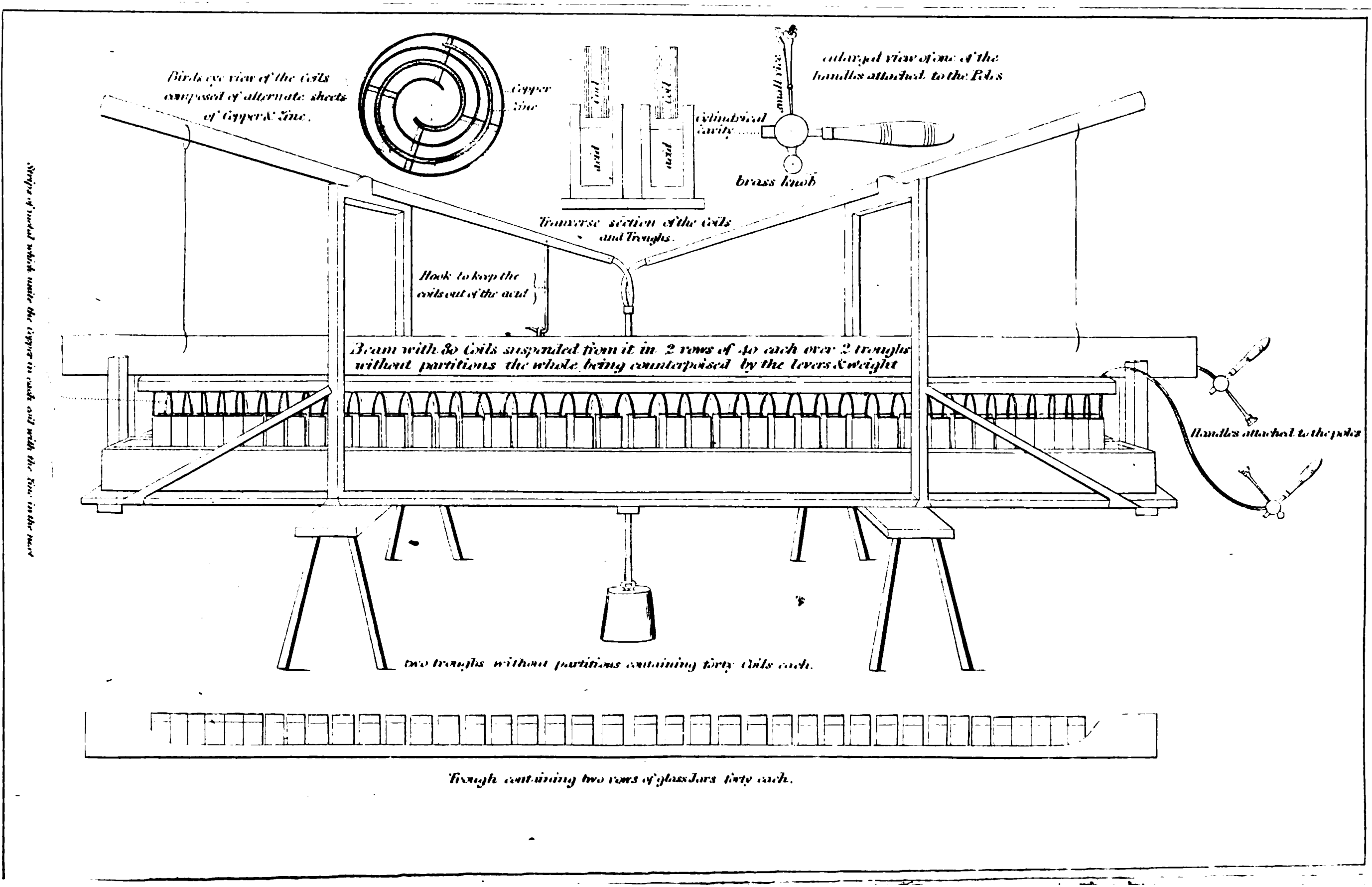
Engraved by J. Warr Jr

Plate 17




Strips of metal which unite the copper in each coil with the zinc in the next
Birds eye view of the Coils composed of alternate sheets of Copper & Zinc.
Copper
Zinc
Coil
Coil
acid
acid
cylindrical cavity
small vice
brass knob
enlarged view of one of the handles attached to the Poles
Transverse section of the Coils and Troughs.
Hook to keep the coils out of the acid
Beam with 80 Coils suspended from it in 2 rows of 40 each over 2 troughs without partitions the whole being counterpoised by the levers & weight
Handles attached to the poles
two troughs without partitions containing forty Coils each.
Trough containing two rows of glass Jars forty each.